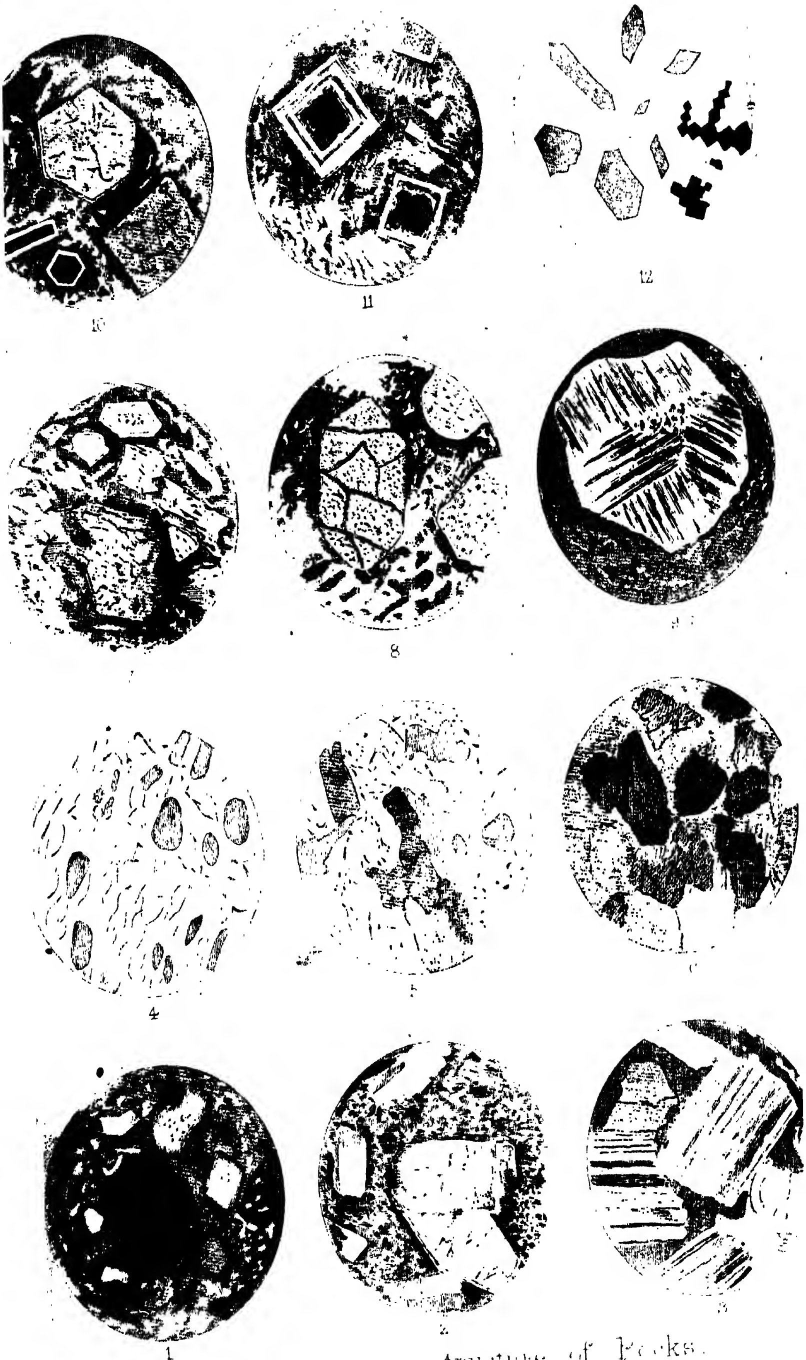

The microscopic structure of Rocks.

THE

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A QUARTERLY MISCELLANY OF
ENTERTAINING AND INSTRUCTIVE ARTICLES ON
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CONTENTS OF VOL. XIV.

POPULAR SCIENCE REVIEW.

ON THE MICROSCOPICAL STRUCTURE OF ROCKS.

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[PLATES CXVI. & CXVII.]

I.

SINCE the day when Ehrenberg, by means of the microscope, proved that certain rocks were almost entirely composed of the siliceous valves of minute organisms, little was done until very recently in the way of a systematic use of that instrument to solve the mysteries of geological science. And yet it stands to reason that there must be very much that is hidden to the eye in the minuter structure of rocks and minerals, that might be detected by means of the microscope, and which might throw a very considerable light upon the origin and history of such rocks and minerals; much that might tell a wondrous story of the various forces that have been at work in building up the materials of which our earth is composed. Little, however, has been done in this country in such inquiries that has been made public. Besides two papers, one published as long ago as 1858 by Mr. Sorby, "On the Microscopic Character of some Crystals,"* and another on "The Microscope in Geology," nine years later, by Mr. David Forbes,† there is, as far as I am aware, no additional information to be obtained upon the subject in our language, except such as may be gleaned from occasional papers in the "Journal of the Geological Society," the "Geological Magazine," and one or two other scientific periodi-

* "Journ. Geol. Soc.," vol. xiv.

† POP. SC. REV., vol. vi.

cals, by Professor Hull, Mr. Samuel Allport—to whose kindness in allowing me to inspect his valuable collection of rock sections I am much indebted—Professor Geikie, and one or two other eminent geologists, who have recognised the value of the microscope in their investigations. The papers to which I allude being merely descriptive of certain rocks, mostly igneous, presupposes a certain amount of knowledge of the subject on the part of the reader. The Germans are ahead of us in these inquiries, and they have recently published one or two important works on the subject.*

In the present paper I purpose showing, as far as the little knowledge I have been able to acquire will enable me, how much may be done with the microscope in unravelling the mysteries of rock structure, trusting that other observers may be stimulated to enter upon this neglected but wide and most fascinating field of study.

To the diligent student there is no rock that will not, on sufficient examination, tell something of its history. The coarsest rocks reveal part of their history to the unaided eye, and the most trivial inspection tells us at once that a conglomerate or a grit must have assumed its present condition through the agency of water; it is the same with most sandstones, clays, and shales. The life-history, too, of such rocks, as well as of the generality of limestones, is told in a similar manner by their fossil contents, which are usually large enough to be seen without any instrumental aid. But when you would inquire further, when you would learn the previous history of the component parts of such rocks, the eye alone can learn but little. Here, then, comes in the use of the microscope, which will find a history written in the minutest chip or grain taken from any given rock. By its means you may also learn whether a rock whose structure is too minute to be understood without it, is to be classed amongst the igneous or the aqueous series. You may learn whether such a rock owes its origin to igneous fluidity or to sublimation; whether it has been deposited as a sediment from water, or crystallised from that fluid at a more or less high temperature; whether it has been subjected to all three agencies, igneous fluidity, sublimation, and heated water, at once or successively; and even something may be learnt as to the amount of heat and pressure it must have undergone in the course of its formation. Again, the microscope will serve

* "Untersuchungen über die mikroscopische Zusammensetzung der Basaltgesteine," by F. Zirkel; Bonn, 1870. "Mikroscopische Beschaffenheit der Mineralien und Gesteine," by F. Zirkel, 1873. "Mikroscopische Physiographie der petrographisch wichtigen Mineralien," by H. Rosenbusch; Stuttgart, 1873.

to show minute organisms, such as foraminifera, diatomaceæ, or faint vegetable traces in rocks in which without its help nothing can be detected. For the purposes of examination we may consider the rocks as divided into the two great classes, igneous and aqueous. It is often difficult to distinguish between some of these without the microscope. There are some fine-grained sandstones that to the eye might at first appear little different from some of the rocks of igneous origin, and *vice versâ;* and even a chemical analysis will sometimes fail to show the difference. But subject a thin section or even splinter of such a rock to the microscope and the difficulty vanishes. The broken and often water-worn fragments of the aqueous rock, derived, it may be, in the first instance, from the breaking up of igneous rocks, will at once reveal its origin.

The igneous rocks are those which have most engaged the attention of the microscopist; the variations of structure, the great variety of minerals composing them, and the great interest attached to their history, give them a pre-eminent place in our estimation, and this the more especially as from their waste and decomposition the bulk of the other rocks have been derived.

Igneous rocks are for the most part crystalline in their structure, although we must at the same time remember that many crystalline rocks, or portions of rocks, have been formed directly from watery solution. Gypsum, calcite, rock salt, and some forms of quartz are examples of such. But in all such cases, those that have been thus formed from water may be readily distinguished from those which own a fiery birth, by means of the microscope. In his valuable paper "On the Microscopic Character of some Crystals," Mr. Sorby calls particular attention to certain minute cavities, almost invariably to be detected in even the smallest crystals, and he shows how these microscopic cavities are the key to the history of the crystal. These cavities he divides into four classes—water, gas, stone, and glass cavities. Water or fluid cavities may often be seen in quartz, and they generally contain a minute bubble, owing to the contraction of the liquid when cooled. When these bubbles are seen to move, as they frequently do, we are at once furnished with a proof that the cavity contains a liquid. The difference between full fluid cavities and those containing only air or gas is marked, the former being nearly invisible by reflected light, the latter shining brilliantly; with transmitted light, these have also a very broad dark outline. A cavity containing an immovable bubble or bubbles is probably a glass cavity, and the surrounding zone of a glass cavity is also wider than that of a fluid cavity; the bright central spot seen with a particular adjustment of the focus is, in the case of spheroidal bubbles, relatively

nearly twice as large in fluid cavities as in glass cavities. Cavities which are filled with crystals are called stone cavities. From a most careful series of experiments, Mr. Sorby also arrives at the following leading conclusions:—

1. Crystals possessing only cavities containing water, more or less saturated with various salts, were formed by being deposited from solution in water.

2. Crystals containing only glass or stone cavities were formed by being deposited from a substance in the state of igneous fusion.

3. Crystals containing only gas cavities were formed by sublimation, or by the solidification of a fused homogeneous substance, unless they are fluid cavities that have lost all their fluid.

4. Crystals possessing fluid cavities, containing a variable amount of crystals, and gradually passing into gas cavities, were formed under the alternate presence of the liquid and a gas.

5. Crystals in which are found both cavities containing water, and cavities containing glass or stone, were formed under great pressure by the combined action of igneous fusion and water.

6. Crystals having these two last-mentioned characters combined were formed, under great pressure, by the united action of igneous fusion, aqueous solution, and gaseous sublimation.

7. Other circumstances being the same, crystals containing few cavities were formed more slowly than those containing more.

Turning now to the application of these principles, it will at once be seen what a light they can throw upon the origin of any particular crystal. By a knowledge of them, we are enabled, for instance, to class the calcite, so frequently crystallised in veins in limestone, with water-formed minerals; we can do the same with gypsum, rock salt, and many other minerals; we can prove that some varieties of quartz have been formed directly from a watery solution. Such forms of quartz as chalcedony, the various forms of agate and jasper, and siliceous sinter are of aqueous origin. Again, we might meet with a specimen of quartz containing water cavities, in which are found cubic crystals of sodic chloride, &c., and, together with these, gas cavities. Such quartz is met with in Cornwall and elsewhere, and we may conclude that it has been "formed above the surface of a hot liquid, and exposed alternately to water and air." On the other hand, take such a rock as the pitchstone of Arran or the trap of the carboniferous period, and a microscopic examination will at once show that the cavities of such are of the glass or stone kind, with occasional gas cavities, and we are justified in pronouncing

such a rock to be of purely igneous origin. All the old trappean rocks, the more recent basalts and pitchstones, modern trachytes and lavas, are all of them found to agree in character; and by the nature of the cavities alone, which are revealed by the microscope, in their component crystals, they are proved to have had a common origin from a state of igneous fusion.

Occasionally we find in some of these rocks large cavities, that have been filled up with zeolites and with calcite, and in these are found water cavities, but no stone or gas cavities; and the conclusion thence arrived at is, that the rock has been exposed to water since its first formation, and its larger cavities have been filled up by deposits held in solution by that water.

Mr. Sorby has called attention to certain blocks ejected from Vesuvius during eruption, which differ from the lavas in containing many minerals not found in these latter. Amongst these blocks are some of limestone, which has been torn from the strata through which the volcano has burst, and in the minerals enclosed in these blocks are found many fluid and gas cavities, as well as stone and glass cavities; and this, taken in combination with certain experiments connected with the nature and fusibility of the contents of some of these cavities, leads to the supposition that the crystals of the ejected blocks were produced at a red heat in the presence of melted stony matter, gases, vapours, and liquid water, saturated with various salts, so that fusion, sublimation, and solution all had a share in their formation. An examination of granitic rocks reveals a structure having some features closely analogous to that of these blocks from Vesuvius. The quartz of these granites is seen to contain cavities of all sorts, fluid, stone, and gas; and this seems to show very clearly that the rocks of the granitic series of all dates originated in a similar manner, that they also were developed "by the combined influence of a dull red heat, liquid water, and partially melted rock," or, in other words, "igneous fusion, aqueous solution, and gaseous sublimation."

The quartz and other minerals so often found in mineral veins would appear to have been deposited in fissures, up which the highly heated water containing them in solution was driven by the heat from below, and in which on its cooling they would be crystallised.

II.

We will turn now to another branch of our subject, and notice, in the next place, how much help is afforded by the microscope in determining the *nature of the minerals* composing rock masses; minerals often present, either in such small quantities or in such minute forms that the eye alone is insuffi-

cient to recognise them. It can, however, be shown that the microscopical structure of most minerals will afford characteristic marks by which they may be readily known. Even in the case of transparent, colourless minerals like rock crystal (quartz), sanidine, leucite, &c., when the microscopical appearance is nearly identical, "their optical properties, and the use of polarised light, afford the means of distinguishing between them with certainty; as also in the event of one substance being present under two forms, as calcite from aragonite, monoclinic from triclinic, felspars, &c." (Forbes). Many rocks have such a minute, close-grained structure, that without the microscope it is impossible to learn anything of their composition; but as soon as we have learnt the characteristic appearance of various minerals in their microscopical forms, we have at once the power to unravel the details of the structure, and the history of the finest-grained rocks, be they slates or basalts, or any analogous forms. The microscope, for instance, it has been well pointed out, will enable us easily to distinguish between a diorite and a dolerite: the hornblende of the former, as soon as we know the microscopical behaviour of that mineral, cannot possibly be mistaken for the augite, which replaces the hornblende in a dolerite.

Again, the microscope shows us how closely allied are the older volcanic rocks, the so-called trappean rocks of palæozoic date, the tertiary anamesites and basalts, and the products of still active volcanoes. Certain common structures are seen to prevail throughout them all. We may, for instance, find in one specimen of dolerite "a close network of crystals in actual contact without any intervening cement; in another we may meet with a vitreous or semi-vitreous base, in which the crystals are embedded; in a third there may be a mass of very minute crystals, amongst which larger ones are porphyritically embedded."*

These varieties of structure are characteristic of similar rocks, whether dating from the earliest period of igneous action with which we are acquainted on our globe, or ejected in our own times from some volcanic vent. When the structure of a rock, whether crystalline, or vitreous, or otherwise, has been determined, we are furnished with a key which will help us to open the secrets of the mode of formation, and the origin of the rock itself.

Turning now to the minute examination of rock structure, let us look at some of the peculiarities of the igneous rocks. Before doing this, however, it may be well to have before us a rough outline of the general characters of these rocks, and from

* S. Allport, F.G.S.

this pass to their minuter structure, and to the distinguishing microscopical characteristics of the principal minerals entering into their composition. The igneous rocks are divided into two great classes, the *acid* and the *basic*, the former containing a much higher percentage of silica than the latter. "The former class is also sometimes known as the felspathic, orthoclastic, or trachytic series, and the latter as the augitic, plagioclastic, or basaltic." To these two divisions must be added an intermediate one, consisting of rocks forming intrusive masses, dykes, &c.

The principal rocks in the acid series are, first, the crystalline, granites, felsites, and felstones. The *granites*, consisting of *quartz*, orthoclase and oligoclase, *felspars* and mica, which is often replaced gradually in masses by hornblende, when the rock becomes syenitic. In these granites we may meet with various adventitious minerals, such as pyrites, marcasite, chalcopyrite, garnet, apatite, and epidote, &c. Felsites and felstones are rocks very various in colour, composed of felspar and quartz, together with some easily decomposable mineral, which takes the place of the mica or hornblende of the granites. The granitic form of felsite is called eurite; the compact varieties are known as felstones. The second class of rocks in the acid series is the glassy; the representatives are pitchstone and obsidian. The basic rocks also consist, first, of crystalline forms, the chief being gabbro, dolerite, anamesite, and basalt. *Gabbro* is composed of *plagioclase felspar*, frequently labradorite; *diallage*, or some other pyroxenic mineral, such as hypersthene, or augite, and *olivine*. Amongst the adventitious minerals are magnetite, pyrites, marcasite, chalcopyrite, biotite, garnet, apatite, epidote, serpentine chlorite, nepheline, leucite, nosean, &c. When the diallage is replaced by augite, and the rock is granular, it is called dolerite; finer grained varieties are anamesite and basalt. The glassy form of basic rocks is known as tachylite.

Amongst the intermediate series of rocks which so frequently form intrusive masses or dykes we find diorite, composed principally of felspar and hornblende, and syenite; porphyrite and phonolite are lavas which may also be classed with these. We may now turn to the structure of these rocks. We frequently find in them a vitreous or glassy base, enclosing crystalline minerals; such a glass appears on a large scale in obsidian and in the pitchstones. A glass under the microscope presents to our view a perfectly structureless character, which possesses no trace of that double refraction when the polariscope is used, which is characteristic of all crystals except those of the cubic system, and therefore it is always dark between crossed prisms. "Felspar may appear dark at the same time, but if the polariser

is rotated a few degrees, and the prisms again crossed by moving the analyser, the felspar transmits light." Thus it is shown that a felsitic base, that at the first glance may appear glassy, will exhibit double refraction. When polarised it will break up as the prisms are rotated into variously-coloured little patches, which gradually assume a more definite form as the axes approach a right angle. In that position it appears as a granular compound of crystalline fragments, amongst which are a few more or less perfect crystals. It has evidently been consolidated whilst undergoing crystallisation. We meet with this kind of base in felsites, porphyrites, &c. The quartz of granite might also at first glance be mistaken frequently for a glassy base, as it is found without any crystalline form, enveloping all the other minerals. It is seen to be structureless under the microscope, and containing numerous fluid and other cavities. But directly it is examined with polarised light, the rotation of the analyser produces a gorgeous display of colours, broken into irregular patches, refracting different tints. Some of the patches show round their edges parallel wavy bands of colour, marking out the individuality of the patches, and showing the manner in which its constituent particles consolidated in independent masses.*

I will now endeavour to point out some of the chief distinguishing marks by which we may recognise the microscopic forms of the minerals ordinarily met with in these igneous rocks. The rock to be examined may be either a granite or a dolerite of the carboniferous period, or a more recent trachyte, or a modern lava, and such a rock may contain as its most frequent constituents three or four or more of the following minerals: quartz, felspar of various species, mica, hornblende, augite, epidote, olivine, leucite, nepheline, apatite, chlorite, nosean, schorl, calcite, as well as some others not quite so common. We must, of course, have our specimen which is to be examined cut sufficiently thin to be transparent, and we must study it both with ordinary and with polarised light. We shall see that some minerals present appearances which are perfectly recognisable in ordinary light, but for the distinction of the greater number of microscopical minerals the use of the polariscope cannot well be dispensed with. And here a word may be said as to the practical use of this instrument. It will enable us readily to distinguish between single and double refracting substances; minerals, for instance, of the cubic from those of other systems. All who have made any use of the polariscope know that when the prisms are crossed the field becomes dark, the polarised beam being unable to pass. Now, if

* S. Allport, F.G.S.

we interpose a single refracting body between the prisms, we shall find that the field is still dark, or, in the case of certain crystals, illuminated only in a feeble but peculiar manner, suggesting a laminated structure in these crystals, which Biot has called "lamellar polarisation," and striking instances of which are presented by leucite and boracite.* On the other hand, all double-refracting minerals between the crossed prisms allow the light to pass to the eye, and it is seen to be variously coloured, according to the thickness of the specimen under examination. There is, however, an exception to be borne in mind—viz. that sections of crystals cut at right angles to the optical axis have no double refraction in that direction, and therefore remain dark between crossed prisms. In the case of compound crystalline bodies, where in ordinary light we seem to have but a homogeneous substance, the polariscope will at once resolve it into its constituent parts, each being distinguished sharply by its colour from its neighbours, showing, to use the convenient German term, "aggregate polarisation."

We may now proceed to the microscopic appearances of the various minerals.† Let us begin with those most commonly met with, and first—*Quartz.* I have already had occasion to notice the appearance of quartz when it occurs as a base, but we very frequently meet with this mineral distinctly crystallised; sometimes the crystals are large and porphyritically embedded in a felspathic matrix. Such crystals may be at once known by their form, and by the magnificent unbroken colours they display when polarised light is used. The peculiar concentric bordering of brilliant colours round a single coloured centre, mentioned in speaking of a quartz base, is very characteristic of this mineral whenever it is met with without any distinct crystalline form, and is owing to the decreasing thickness of the individual masses around their edges. Cavities of all sorts are abundant in quartz.

Felspar.—The various species of felspar present striking differences when examined microscopically, and the monoclinic forms are readily distinguished from the triclinic, as sanidine and orthoclase from plagioclase and labradorite.

Sanidine.—Sanidine is usually seen, in thin sections, either well crystallised or in crystalline grains and fragments; its forms when perfectly crystallised are various but characteristic. Sanidine is generally very pure and transparent, though occasionally it encloses other minerals, such as plagioclase, nephe-

* In the case of Boracite this lamellar polarisation has been considered to be owing to interposed lamina of a double-refracting substance, slightly differing from it in chemical composition, which M. Volger has called parasite.

† Authorities, Rosenbusch, Zirkel, &c.

line, nosean, leucite, hornblende, augite, and magnetite. Long needle-shaped crystals (belonites) are sometimes common in it. Broken sanidines are often found enclosed in a trachytic base, and from their presence we can gather that they were already formed whilst the mineral mass was in motion, and thus got broken.

Orthoclase.—Orthoclase, whilst presenting nearly similar crystalline forms to those of sanidine, differs from it in being very seldom clear. It is a usual component of granites and porphyries, as well as of other igneous rocks. The flesh-coloured crystals so common in some granites belong to the orthoclase series. When polarised, orthoclase often shows a remarkable irregular, banded structure, the bands being interrupted, and crossed by other bands at right angles to the former, and having a grating-like appearance. In some cases these are seen with a high power to be caused by an infinity of cells or tubes penetrating the crystal in two directions, coincident with the planes of cleavage; sometimes this banding will be in one direction only, but wavy. The bands frequently give the appearance of twin striping, and have also been supposed to be owing to an intergrowth of orthoclase and albite, or perthite. Quartz is often found enclosed in orthoclase, and occasionally a net-like intergrowth of these two minerals may be observed. On account of the general opacity of orthoclase, it is difficult to recognise the various microlitic minerals contained in it. It is said that gas cavities have never been seen in the orthoclase of granites, although fluid enclosures have sometimes been found. Minute crystals of specular iron in regular layers are abundant in some specimens, and often give a red tint to orthoclase and perthite.

Triclinic Felspar.—The triclinic felspars are known at once under the microscope by their striped appearance. Parallel bands of colour, which change with each half turn of the analyser to the complementary tint, make this mineral to be one of the most beautiful of objects in the polariscope. They are equally well seen in plagioclase and in labradorite, and might well suggest some gorgeous patterns to designers of striped fabrics. Without the polariscope these bands may be faintly seen as fine dark lines in the crystal. This appearance is owing to the twin formation of these felspars, and as no other mineral forms such polysynthetic crystals, this is an unfailing test of its presence. Microlites of augite and hæmatite are not unfrequent in some specimens, as well as cavities. Water cavities are found in the plagioclase of the gabbros and hypersthenic rocks.

Twin Crystals.—Before passing to the next mineral, it will be well, perhaps, to notice here the peculiarity of twin formations so splendidly seen in plagioclase. It is not always possible

to recognise a twin crystal under ordinary light, on account of the way in which it may be cut; but with polarised light it can always be seen with great certainty in the case of all double-refracting minerals, owing to the reversal of the optic axes, which causes the appearance of different colours in the different laminæ of the crystal. It may also be observed, that whenever the optic axis of one of the twins coincides with that of the Nichol prism that twin will appear dark, whilst the other will be coloured, and this effect will, of course, be reversed with the reversal of the Nichol. This phenomenon of twin formation is very commonly met with in microscopic sections of many minerals.

Mica.—Examining our minerals rather in the order of their importance than of their strict classification, we will look next at some of the various species of mica. The ordinary mica found in granite is potash mica, sometimes called biaxial mica, or muscovite.

Muscovite forms table-shaped crystals, and its sections coincide with the chief plane of cleavage, and show an irregular polygonal shape. Owing to the laminated structure of mica, its sections show a chaos of fine lines and of Newton's rings on the surface, which mark the boundaries of its torn leaves, some of which may be only $\frac{1}{250000}$ part of an inch thick. Its leaves are sometimes differently arranged as regards their optic axes—"differently oriented," the Germans would say—and thus when polarised such a mica will never be dark in a horizontal position, as its planes of vibration can never in all the leaflets coincide with those of the polariser and analyser. Mica, as a rule, does not enclose many other mineral substances; occasionally apatite needles are found in it, pretty crystals of hæmatite, and also magnetite, whilst between its leaves may sometimes be seen dendritic markings. In the mica of granite fluid cavities are not uncommon. It is usually very transparent, and, owing to this, shows brighter colours than biotite, although it is difficult under the microscope to distinguish between the two. Mica is dichroic, but usually manifests only clearer or darker tints of the same colour.

Biotite.—Biotite, or uniaxial or magnesia mica, has hexagonal crystals, but is generally seen in thin, irregular, polygonal, or roundish leaflets, or elongated tables. In the former case it has a smooth, shining surface, in the latter is laminated. As I have just observed, its microscopic characteristics are but slight. The little leaflets, which are perpendicular to the small axis, remain dark between crossed prisms. Those cut parallel to the axis only become so when the direction of their thin stripes is parallel to the chief diagonal of the Nichol prism. The powerful dichroism[1] of biotite is one of its most characteristic marks

when the polariser alone is used, and if the direction of the cleavage is perpendicular to its shorter diagonal, the colours may be greenish yellow to brown; if the direction of the two is parallel, we get dark brown to black owing to the greater absorption. Biotite is distinguished from other dichroic minerals, such as epidote and hornblende, by the absence of the markėd pleochroism which these present, and from tourmaline by its fine striation.

Talc.—Talc, which occurs both in large quantities in talc slate, and also in little curved scales and crystals as a constituent of some granular rocks, like mica shows both by transmitted as well as by reflected light similar irregular lines and brilliant coloured rings, owing, as in that mineral, to the partial separation of its leaflets. It may be known from mica and also from chlorite in possessing no perceptible dichroism.

Chlorite.—Chlorite forms little green leaflets, and scale-like aggregations in various rocks. Its scales or leaflets are frequently arranged in vermicular or radiating forms, caused by their partially overlapping each other; it is also found in concentric layers, like the coats of an onion. In many specimens the leaflets seem to consist of twisted or irregularly intergrown fibres. Sometimes leaflets of chlorite look like large green glass cavities, and present a beautiful appearance in sections of the chloritic schists. Now and then hexagonal scales will be seen, which remain dark between the crossed prisms. The polarisation colours of chlorite are often very feeble; blue and brown tints prevail. The mineral shows decided dichroism, although of varied strength in different specimens.

Hornblende.—We will next turn to hornblende, a widely dispersed and very important constituent of many rocks. It is found distinctly crystallised, frequently in six-sided forms, but it is more often found in crystalline masses, which might be called crystalloids, and in sheaf-shaped aggregates: these are especially common in diorite. It may be at once distinguished from augite, which mineral it resembles somewhat in its sections, although its prism angle is larger, by its fibrous structure; this serves also to distinguish it from augite, when as uralite its crystalline form is the same. Twin crystals also are not so common in hornblende as they are in augite, but one of the most striking characteristic features of hornblende is its strong dichroism, the "orientation" of which, to use the German term, distinguishes it from mica, which it rather resembles in form in some specimens. Besides its dichroism, its striking pleochroism might well serve to distinguish hornblende from biotite, augite, or diallage. Epidote might possibly be mistaken for it, but the dichroism of this mineral is not so strong.

Augite.—Augite is a mineral as important in rock formation as hornblende, and is as constantly present in dolerites as the latter is in diorites. In the microscope it usually is very recognisable, on account of its brownish or brownish yellow tinge, and its crystalline form is frequently very distinct, and well defined from the surrounding mineral matter. Some of the crystals will be perfect at one extremity and broken at the other. The crystals are also often grouped in masses, or a number of small crystals will be united so as to form apparently a single one; in these cases polarised light will show the composite nature of the seemingly simple crystal. Dislocated crystals of augite are very frequent in some rocks. Augite crystals have a somewhat broken-looking surface, and irregular flaws may be seen in them with transmitted light. Vast quantities of minute well-formed transparent light yellowish brown crystals of augite sometimes abound in basalt rock, also needles of this mineral, which occasionally are curiously shaped, being curved at one end like a hook, or swollen like a club, or sometimes both extremities will be split into dichotomous points. Very numerous microlites are enclosed in augite crystals; amongst them are leucite, biotite, magnetite, &c. Sometimes the augite crystal will be a mere thin wall, enclosing a multitude of microscopic minerals. Cavities of all sorts are also frequent in augite. The double refraction of augite is powerful, and in thin sections it polarises with brilliant colours.

Diallage.—Diallage, when crystallised, corresponds with augite, but more frequently it is found in granular aggregations, and fills up or borders cavities in the matrix. Its usual colour is green, but it is sometimes brownish, on account of enclosed mineral matter. Sections of diallage show a distinct striping parallel to the chief axis of the crystal, and a concentric, shaley structure is sometimes denoted by little colour rings. Between its laminæ a secondary formation of calcite is occasionally met with, also hornblende, but this is an original formation. It encloses, like augite, various other minerals, and on its surface it often exhibits a kind of metallic lustre. Its slight absorptive optical properties easily prevent its being mistaken for hornblende, with which its laminated texture might possibly lead some to confound its sections.

Melilite.—Melilite is a mineral sometimes found coating porous cavities in lavas, and also as a chief component of some of the basic rocks, but is never met with in the felspathic basalts. Its appearance in thin sections will be in quadrangular or long rectangular forms, but somewhat ill-defined; more often it is met with in irregular aggregations. Melilite has a coarsish surface striping, always in the direction of the chief axis—that this is only a surface striping is proved by its not

being interrupted by enclosed minerals;—and this is pointed out as one of its best characteristics under the microscope. Its colour is greenish or lemon yellow; when polarised it shows rich Berlin blue and brownish yellow tints.

Olivine.—The next mineral to be noticed is olivine. It is constantly met with in the older trappean rocks, as well as in the more recent basalts and lavas. It has been observed that a special characteristic of basaltic olivine is that its crystals are fragmentary, and frequently the separated parts of individual crystals may be recognised, thus most clearly proving the motion of the mineral mass in which they are enclosed. Olivine crystals are in thin sections, greenish grey; if very thin, colourless. It is an easy mineral to distinguish, owing to its peculiar granular or undulated-looking surface, and it is also frequently fissured, which gives it a veined appearance. It polarises with a peculiar opalescent play of rosy and green colours. Olivine, more than any other mineral, is inclined to decomposition, and this change may be observed to begin along its capillary fissures, in which fibrous deposits of oxide of iron and of serpentine take place, when its crystals have beautiful green reticulations traversing their substance. Sometimes the olivine will be completely pseudomorphosed into serpentine, and it is worthy of note that long ago, in the earlier editions of Sir C. Lyell's Geological Manual, it was observed that "as olivine differs but slightly in its mineral composition from serpentine, containing even a larger proportion of magnesia than serpentine, it had been suggested, with much probability, that in the course of ages some basalts, highly charged with olivine, may be turned by metamorphic action into serpentine." Olivine is very generally met with as a pseudomorph, the irregular patches into which the polariscope shows it to be broken up at once showing the distinction between an aggregate of mineral matter and a single uniform crystal. Fine hexagonal crystals of this mineral are frequent in some of the German basalts.

Leucite.—Leucite is an important constituent of Vesuvian and of some other lavas, in which it seems, in part, to replace the felspar of other similar lavas. It is also frequently present in smaller quantities in many of the igneous rocks. Its microscopic recognition is easy. It is usually met with in rounded grains massed together in bands; its crystal sections are octohedral, its angles are often rounded. Very fine large octohedrons are frequently found in the Vesuvian rocks. Under the microscope, when the polariscope is used, it presents, especially in the smaller grains and crystals, the appearance of a glass, but in the larger we may often see a very marked and characteristic feature—viz. those interference spectra which have

already been noticed, under the name of lamellar polarisation. Between crossed prisms the leucite crystal will exhibit a remarkable series of parallel stripings, of a dark or bluish grey or blue colour, crossing each other at right angles, or at an angle of 60°. On the rotation of the analyser the black or dark stripes will become clear, and the blue grey presenting the usual phases of double-refracting crystals. Zirkel has considered this curious optical effect to be owing to an intergrowth of two different species of leucite, one of which is double refracting. Another writer, Von Rath, shows that the leucites have a great tendency to twin formation. Analcime is another mineral which exhibits a somewhat similar lamellar polarisation, and which has been referred to as a laminated structure, in which the laminæ are separated by thin strata of air; and by some observers the behaviour of leucite has been set down to this kind of structure. Another distinguishing feature of leucite consists in the abundance of enclosed microlites it contains, sometimes irregularly arranged, but more frequently found in central groups or in concentric rings of stone cavities, near the circumference of the crystal. Some of these microlites will be found to be augite needles, and grains of a greenish or yellowish colour, others grains of magnetite. Besides the stone cavities, leucite also contains numerous gas and glass cavities, the latter often marked by diminutive immovable bubbles.

Nepheline.—Nepheline, a frequent mineral in volcanic rocks, plays a very important part in some basalts and lavas. It occurs very generally in hexagonal or rectangular forms. The hexagons being cut at right angles to the axis will not polarise, but sections which are parallel to it polarise well with a light brownish yellow or a light greyish blue colour. What appears to be a fine grey dust is sometimes seen in nepheline crystals, which with a high power may perhaps be resolvable into glass cavities. Very small green microlites, parallel to the long axis of the crystal, are also found in nepheline. Although nepheline is a very stable mineral, yet sometimes its crystals will show an aggregate polarisation, and the whole crystal will occasionally be found converted into an aggregation of zeolites. An oily-looking, flesh or green coloured variety of nepheline, which is seldom distinctly crystallised, is occasionally found to take the place of nepheline in the older igneous rocks; this is elæolite, and may be considered in reference to nepheline to be what orthoclase is to sanidine.

Apatite.—It is somewhat difficult to distinguish between nepheline and apatite, but careful observation will show that where these minerals come together so as to be compared, the hexagonal crystals of nepheline are somewhat larger than those of apatite; and it may also be observed, that whilst nepheline

will occur in short colourless rectangles, the apatite will form long colourless needles, both minerals having hexagonal sections.

Sodalite.—Sodalite is a representative of a group of isomorphic regular minerals found in volcanic rocks. Microscopic sections show dodecahedral forms, and they are often very translucent, though frequently also full of various microlitic enclosures and large gas cavities, and glass cavities containing bubbles; occasionally fluid cavities may be also found in sodalite from Vesuvius.

Nosean.—Noseán or noseite is a brown or grey variety of hauyne, of which lapis lazuli is the well-known blue form. Nosean is occasionally found in volcanic rocks, and may be readily known in the microscope by its quadrangular crystals, which are filled with dark granular specks, occupying the centre or else symmetrically following the planes of the crystal.

Epidote.—Epidote is found in some granitic, dioritic, and other rocks, in granular crystallised forms, and it is frequently seen in small elongated crystals, clouded with a rather dirty green colour; in some specimens it seems to have a radiate fibrous structure, and it shows a play of colours when polarised, green, yellow, and brown tints prevailing. Epidote is associated with quartz in some rocks, and when mixed with more or less of that mineral, and sometimes with garnet, it forms the rarer mineral, epidosite.

Serpentine.—Serpentine, which is often found in enormous masses, in the microscope shows a ribbon-like structure of deep-coloured greenish or bluish green, nearly opaque mineral matter, and in thin sections a kind of laminated or net-work appearance is produced; on the outer edge there may be often observed brush-like aggregations of needles pointing towards the interior of the serpentine. In the polariscope serpentine shows double refraction.

Iron.—Iron is constantly present in igneous rocks of every age, usually in the form of crystals and grains of magnetite, occasionally as titaniferous iron, and as specular iron and hæmatite. Curious clusters of opaque magnetite crystals are frequent. Translucent crystalline plates of hæmatite are often found in felspar, and it is owing to the light reflected from these that the variety of oligoclase called sunstone owes its beautiful opalescent appearance.

Calcite.—We may consider now one or two minerals which usually occur as secondary formations, filling up fissures and cavities in the igneous rocks. One of the most important of these is calcite, which in its varied forms is one of the most abundant of minerals, occurring not merely as an occasional after product in volcanic rocks, but still more frequently in

purely aqueous deposits. In its microscopic forms it shows a banded and delicately iridescent structure, the bands coinciding with the rhomboidal shape of its crystals. This structure is beautifully displayed in many marbles. Calcite often is found filling the amygdaloid cavities of trappean rocks, and is frequently surrounded in them by a green chloritic coating. Water cavities are abundant in it, proving it to be a secondary product deposited from watery solution in the empty spaces which were originally gas bubbles in these rocks.

Aragonite.—Aragonite, another form of calcic carbonate, differs altogether from calcite by its cleavage, which, instead of being rhomboidal, is conchoidal. Under the microscope it has a foliated appearance. In some sections of Carrara marble this is well shown, and if this is the general form of that marble, it may serve to explain its admirable adaptability to the purposes of the sculptor.

Chalcedony.—Chalcedony is occasionally found in amygdaloid spaces, as well as forming the mass of agates, and is an exquisitely beautiful object in the polariscope, showing a radiated structure which displays the most gorgeous colours, as well as fine illustrations of interference spectra.

Delessite.—Delessite is another mineral not unfrequently found in amygdaloids, either completely filling up the cavities or else coating their sides. It has a concentric banded structure, with a radiate growth between the bands, or rather cutting through them. The concentric lines follow the form of the cavity in which the delessite is found. This structure is probably owing to intermittences of formation, and may be compared with the season rings of trees. The beautiful mossy-looking growth in some Indian agates has been considered to be delessite. The colour of this mineral is green, and it is transparent and pleochroic. Between crossed prisms the radial forms of delessite, especially sections across amygdaloid formations, show the interference cross very beautifully in the polariscope.

Zeolites.—There are other secondary formations found in igneous rocks besides those mentioned. Zeolites of various species are common. All these formations may be found in microscopical as well as in the larger amygdaloidal cavities. Amongst them all we may observe the same tendency to a concentric or fibrous structure. Their natural colours are very various; yellow, brown, and green tints prevail, together with white or colourless specimens, which may be calcite, aragonite, or zeolite, and sometimes chalybite.

Aqueous or Sedimentary Rocks.—Before bringing this paper to a close, a few words may be added upon the general characters of the aqueous rocks under the microscope. We are

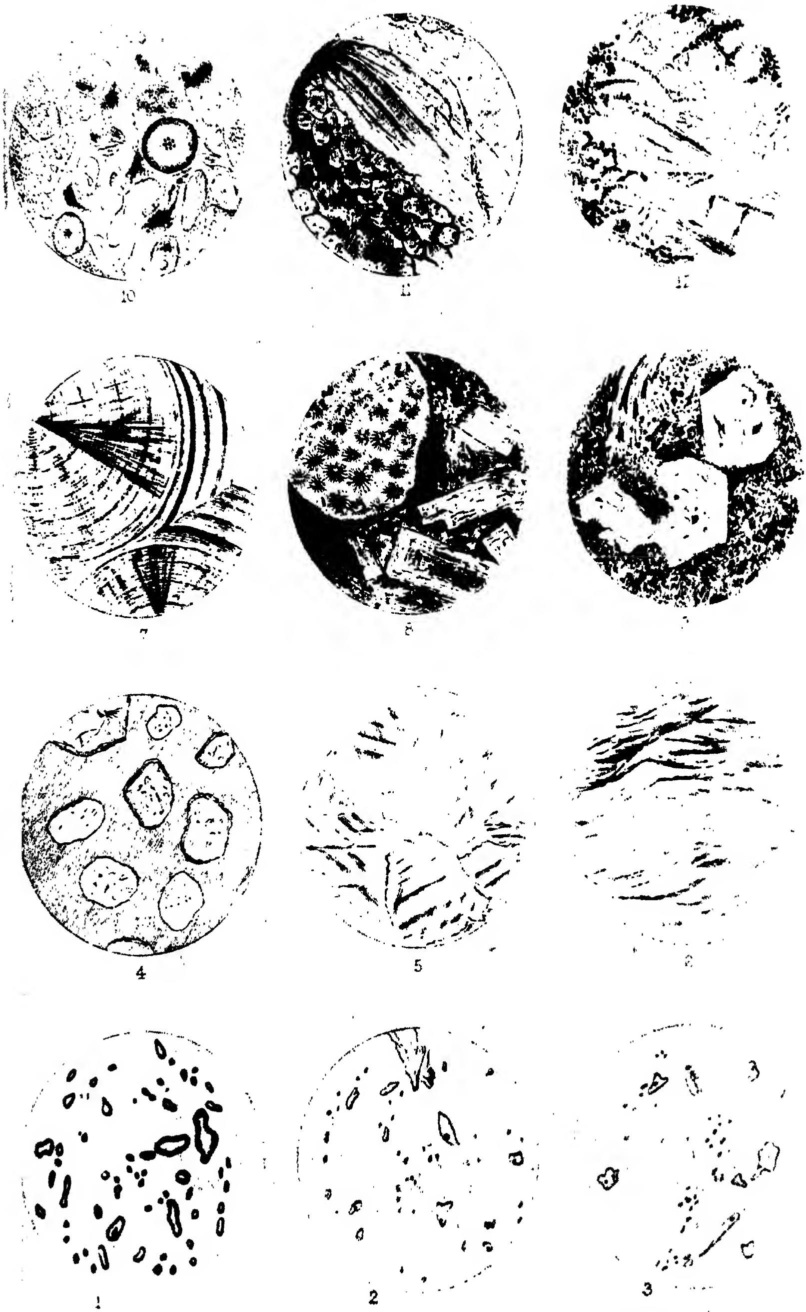
at once struck with the very different appearance of these compared with those just described. Take, for instance, a thin slice of a sandstone, no matter how fine-grained it may be; it is seen to be an aggregate of particles, more or less water-worn, of quartz and other minerals, evidently derived from the breaking up of older rocks. Clays, shales, and most of the slate rocks present a somewhat similar appearance, although with a more minute structure, which in the slatey rocks is sometimes considerably affected by the effects of pressure, as well as by other agencies since their first deposition. The microscope, again, will often bring to view in these rocks very numerous remains of organisms. Some of the clays and shales and limestones contain foraminifera, diatomaceæ, and other fossil traces of the life of the period. Occasionally rocks are found, such as some of the foreign slates and clays, that are composed of little else than diatomaceæ and sponge spicules. The tripoli and semi-opal of Bilin, in Bohemia, present fine examples of such rocks. Chalk, too, when subjected to microscopic examination, reveals instantly its purely organic origin; it is seen to be built up almost entirely of minute organic bodies—foraminifera, sponge spicules, fragments of bryozoa, &c. So bog iron ore can be traced to a similar origin. The older limestones, also, even when no fossils appear to be present, are seen, when sufficiently thin sections are prepared, to be similarly composed; and the microscope thus helps us to correlate the limestone and the chalk of former ages with formations of a like nature, accumulating at the present day in the bed of the ocean.

To the microscope we owe the discovery of what is possibly the earliest existing trace of organic life on our earth; the eozoon canadense, which is, if the opinions of those most competent to judge be accepted, the remains of a gigantic foraminifer, entombed in the laurentian serpentine.

It is, perhaps, hardly necessary to observe how the microscope will also enable the skilled observer to determine from a small fragment of bone or of a tooth the nature of the animal to which it belonged; or, once more, in the faint traces of vegetable origin frequently met with in certain rocks, to gather some idea of the plant life of the period. We all know how abundantly a microscopic examination of coal and of the carboniferous vegetation has repaid the labour spent upon it, enabling us to form tolerably correct notions as to the nature of the vast flora which clothed a great part of the earth's surface in bygone ages.

With these scanty and, I fear, very imperfect notes upon a wide and most interesting field of study, I bring my paper to a close, and I trust that it will not be very long before we find many English geologists awaking to the great importance of this branch of their science. That it will well repay the most earnest attention there can be little doubt. To the petrologist,

Plate XXVI.



The microscopic structure of Rocks

the mineralogist, and the physicist the intelligent use of the microscope is invaluable, and I need scarcely add, that in this, as in every branch of scientific inquiry, every fresh glimpse we obtain brings new beauties to light.

EXPLANATION OF PLATES.

CXVI.

FIG. 1. Quartz, Quartziferous-Porphyry, Saulieu, polarised.
FIG. 2. Sanidine in Domite, Puy de Dôme, polarised.
FIG. 3. Triclinic Felspar, polarised.
FIG. 4. Chlorite, Chloritic Schist, nat.
FIG. 5. Biotite, Germany, seen with polariser alone.
FIG. 6. Hornblende in Diorite, seen with polariser alone.
FIG. 7. Augite, Augitic Porphyry, Germany.
FIG. 8. Olivine, Somma, Vesuvius, &c., polarised.
FIG. 9. Leucite, Somma, Vesuvius, polarised.
FIG. 10. Nepheline and Apatite, Katzenbuckel, nat.
FIG. 11. Nosean, nat.
FIG. 12. Hæmatite and Magnetite, nat.

(*All magnified* 26 *diam.*)

CXVII.

FIG. 1. Gas Cavities, in Lava, Hecla.
FIG. 2. Water Cavities, in Quartz, Cornwall.
FIG. 3. Glass Cavities, in Quartz, Cornwall.
FIG. 4. Glass and Stone Cavities, in Lava, Hawaii.
FIG. 5. Calcite, Marble, Ephesus.
FIG. 6. Aragonite, Marble, Carrara.
FIG. 7. Chalcedony, Cornwall.
FIG. 8. Fibrous Zeolite, in Dolerite, Germany.
FIG. 9. Mica, in Trachyte, Germany.
FIG. 10. Organisms, in Limestone, Derbyshire.
FIG. 11. Vegetable Remains, in Coal.
FIG. 12. Serpentine, Cornwall, 26 diam.

(*Magnified* 56 *diam.*)

THE NEBULAR HYPOTHESIS: ITS PRESENT CONDITION.

By JOHN J. PLUMMER, M.A.

IN the whole range of science there is no theory which has attracted so much attention, has passed through so many vicissitudes, and has been so earnestly and fondly supported in the face of opposing evidence, as the nebular hypothesis of Laplace. This has arisen, doubtless, to some extent from the respect due to the very eminent astronomers by whom it was first suggested and promulgated, but perhaps still more to the nature of the hypothesis itself, and to the fact that many otherwise unexplained phenomena find in it a satisfactory solution. The whole course of scientific progress has led us to look for the most simple laws in order to explain the most apparently complicated results; and such a law the nebular hypothesis would become, were it possible to give to it such a high degree of probability as at present serves for the demonstration of the Newtonian law of gravitation, or of the undulatory theory of light. That it may one day attain to this degree of certainty, and be recognised as an established truth, is the hope of many who are fascinated alike by its simplicity and its comprehensiveness—a hope that has often served to sustain it when the bulk of evidence has not appeared to be in its favour, and one in which the writer to some extent indulges, although well aware that it may require to undergo considerable modification before it reaches that exalted position.

Previously to the revelations of the spectroscope, the nebular hypothesis stood at a very low ebb. The gradually increased powers of telescopes, culminating in the gigantic reflector of Lord Rosse, had one by one reduced the number of the so-called nebulæ, by resolving them into clusters of distant stars, very closely packed together, until, although a large number still continued nebulous in appearance under all circumstances, it seemed very probable indeed that indefinitely increased telescopic power was all that was needed to resolve the remainder. Still it retained a few believers, loth to relinquish the insight

into the origin of the solar system which it holds out, and ready to seize at once on the important discovery of true gaseous nebulæ by Mr. Huggins as direct confirmation of the hypothesis. There can be no question that the proved existence of immense masses of gaseous matter does place the theory upon a much firmer footing than before; at least, the speculations of Sir William Herschel are now established, notwithstanding that the superstructure raised thereon by Kant and Laplace is little, if, indeed, as we shall see further, at all supported by it.

For this important advance in our knowledge we are indebted to the spectroscope. When all other means had failed to give us faithful indications of the existence of remote gaseous bodies, this invaluable instrument at once decided without question that, of the nebulæ unresolved by the largest and most powerful telescopes, a considerable proportion are simply mechanical mixtures of three gases, two of which are well known to us, namely, nitrogen and hydrogen; and the third, although unknown or unidentified, is probably of somewhat similar character—that is, an elementary, non-liquefiable gas. It is not improbable that it may even be a terrestrial element, for our knowledge of the variety of spectra obtainable from the same substance, under different circumstances, is still too deficient to enable us to speak positively on this point. But the spectroscope is capable of telling us still more regarding the nature of the light analysed by it, and it is here that the evidence it gives is unfavourable to the hypothesis of Laplace. The density of the gas from which the light emanates produces an effect upon the spectrum, and is measured by the breadth of the lines composing it. Now, the nebular hypothesis requires as a necessary corollary—and it has accordingly always been admitted as such—that nebulæ of every degree of condensation should be found in the heavens, and the variations of brilliancy of these bodies has therefore been pointed out as evidence of variation of density. The width of the spectral lines, however, provides us with a much more certain, delicate, and reliable test. From the observations of Dr. Huggins, it would appear that the bright lines in the nebular spectra present no appreciable difference of thickness in all those cases in which it has been possible to use a very narrow slit. The lines have invariably been found to be exceedingly fine; and hence we are furnished with distinct proof that the gases so examined are not only of equal or nearly equal density, but that they exist in a state of very low tension; facts, as I have already stated, which are fatal to the hypothesis. It is, of course, possible that similarly as the numerous lines of the spectra of nitrogen and hydrogen are reduced to two or three in the nebular spectrum, in consequence of the faintness of the light operated upon, so may

the width of the lines be diminished from a like cause; but with this I have nothing to do. It is my object merely to show that at present, so far as the spectroscope has afforded us increased knowledge of the state of these bodies, it is fatal to the theory, and it remains for those who uphold it in its integrity to establish by experiment that the spectrum of a dense gas, when very faint, not only is reduced to a single line, but that that line itself is narrow when the slit is narrow, as in the case of rarefied gases. Unless this proposition can be established, there remains no alternative but to reject the hypothesis, as an inviting but fallacious guide to the explanation of the origin of the solar system, and to look for some new theory, or for some modification of the old one, for the solution of those problems which it would otherwise afford.

There are still further reasons for believing that the nebular hypothesis in its old form is not altogether trustworthy, and, though of less weight, may help to turn the scale, at the same time that they prepare the ground for an altered conception of it, free from these objections. It has been necessary hitherto to assume that the nebulous matter existed originally at a great heat, without suggesting, it seems to me, any sufficient force by which this high temperature was reached. This is, at least, wanting in completeness, especially as there is at hand, as I hope to show, the means by which the matter may have been thus raised in temperature. But a still more fatal objection would appear to be, that the gases which have been identified in the nebulæ do not seem to be, in themselves, adequate to form a system such as our own, unless by the addition of foreign matter from without. Probably no advocate of Mr. Lockyer's theory of the disassociation of the material molecules into their primary or truly elementary components by enormous heat, will go so far as to imagine that the two known gaseous constituents of the nebulæ, together with one other unknown substance, is all that is essential to form a globe such as our own sun, especially when it has been proved that the actual materials required are known to exist in the immediate neighbourhood, and appear to have no other use in the economy of the universe than that of forming with the nebulæ suns and systems such as our own.

It is, perhaps, scarcely necessary to point out that it is to the cometary system that I allude, as capable of supplying the necessary material from without, as well as of causing the enormous evolution of heat of which I have spoken; but there are one or two misconceptions which must be cleared away before the mind is prepared to admit the possibility of such a circumstance. These misconceptions have reference, firstly, to the distance of the nebulæ from our own system, and hence to

their true volume; and secondly, to the magnitude, or rather the mass, of the generality of comets. As regards the former, it has clearly arisen from the unfortunate association of the true gaseous nebulæ with clusters of stars. Of the enormous distances of the latter from us there can be no doubt; but now that an entirely different class of objects has been proved to exist in the heavens, similar only in appearance to the most remote clusters, there can be no reason to suppose that these are at the like distances. Indeed, it would seem more probable that they are actually nearer to us, at least in some instances, than the nearest fixed stars themselves, for the enormous magnitude which must be attributed to such a mass as the great nebula in Orion, if it be supposed to be at a very much greater distance, must act as a bar to such an assumption. Indeed, the mind experiences a sense of relief in believing that the nebulæ are our nearest neighbours, and the uniformity of nature, which does not offer to our contemplation masses of matter incomparably greater than those we have to deal with in the solar system, seems to require that the nebulæ should not be conceived as of such surpassing magnitude. If this be admitted, it brings these objects almost within the range of comets visiting the solar system; but there are, doubtless, in the heavens numerous groups or congeries of comets similar to these, not to speak of those wanderers which move in parabolic or hyperbolic orbits, and which only require infinite time to travel infinite distance. Thus the wide gulfs separating star from star, and which appear only to exist to allow of the free revolution of stellar systems, may be the theatre not only of the movements of comets, but also of the evolution of new worlds.

The belief in the insignificant mass of most comets, which is also, I think, open to question, is grounded on more substantial reasons. One comet (Encke's) has actually been weighed against the smallest of our planets, Mercury, and has kicked the beam, but perhaps no more unfortunate instance for the experiment could have been selected than this. It is a comet without stellar nucleus, and one that has made so many revolutions round the sun, that supposing, as we have reason for doing, it loses some portion of its matter at each visit, it must clearly have been a very much wasted body at the time (1842) when Encke made its perturbations by the planet Mercury the subject of his able researches. The only other comet that has given us a favourable opportunity of weighing it against one of the planets is Lexell's, which in 1767 and 1779 must have approached very near to Jupiter, without deranging to any extent, so far as we are aware, his system of satellites. Laplace has proved that this comet had certainly less than $\frac{1}{5000}$th part of the earth's mass, but there is a very considerable difference be-

tween this evaluation and the "few pounds or ounces" which we sometimes hear of as a probable estimate of their weight. Let it be further remembered that Lexell's comet, like Encke's, was one of the comets of short period, which are admittedly the least considerable of their class, and we must acknowledge that the belief in the diminutive mass of comets rests upon insecure if not insufficient evidence. The important discovery that comets in their orbits are accompanied by streams of meteors, and that they themselves are either meteors of very unusual size, or a dense cluster of such bodies, proves that they must have a mass at least comparable with, if they do not often exceed, that given by Laplace as the maximum possible for Lexell's comet.

Having to some extent removed these misconceptions as to the masses of the comets and of the nebulæ, it is next to be considered whether the cometary systems are capable of supplying the nebulous matter with the requisite material for the formation of new suns, and here our imperfect knowledge of the constitution of the former acts as a serious drawback. It would seem certain, however, that the composition of comets is very various. One substance alone that is known to us at present has been discovered, from spectroscopic analysis, as existing in comets, and to form it would appear, in those cases in which it is found, the sole constituent. This substance is carbon,* but it has been identified only in three or four comets out of a considerable number whose spectra have been examined. The great comet of the past year is one of those whose spectrum has been thus identified. Others have yielded spectra which, being simple in character and very similar in appearance to that of carbon, may possibly belong to some substance of analogous properties; at least, it is likely that a single uncombined element will be found, on increased knowledge, to form their principal or sole constituent. Again, it is not improbable that other comets may be of like composition to the meteors, many of which have been analysed by the ordinary methods of the chemist; but whether this is so or not, since these latter follow in the track of comets, they must suffer the same catastrophes. The meteors that have fallen upon the earth have been found to contain a large number of terrestrial elements—iron, in a native, uncombined form, and in great quantity; cobalt, nickel, sulphur, silica, in the form of augite; molybdenum, tin, copper,

* It is often stated that the material of comets yielding the carbon spectrum must be a hydro-carbon; but it is to be remarked that none of the lines of hydrogen have ever been seen, and the assumption is therefore an entirely gratuitous one, made to get over the difficulty of the refractory nature of carbon.

and a number of other metals in smaller quantity. All these are substances of an entirely different character from those elements identified as composing the nebulæ. The former are among the most refractory of chemical elements; the latter quite defy our utmost attempts to liquefy them. In both they appear to exist in an uncombined form, though their union would go far to supply the materials of a world such as ours. Some important elements, as oxygen,* are wanting, it is true; but it must be remembered that we know already of two important constituents which we are unable to identify with terrestrial elements, namely, the substance which at least as frequently as carbon is found the sole component of comets, and the gas equally unknown which exists along with nitrogen and hydrogen in the nebulæ.

Although in the system of Laplace the cometary element held only a very subordinate position, it must not be imagined that it was neglected altogether. On the contrary, Laplace, with that far-reaching power of generalisation which is characteristic of great minds, perceived that the encounter of comet with nebula was inevitable, and the mechanical problem of the diminution of velocity, in consequence of the former moving impeded through the gases of the latter, received from him much attention. He perceived that a comet once within the power of attraction of a nebula had no chance of escape, but must revolve round its centre of gravity in an ever diminishing spiral; but, unacquainted with the peculiar chemical constitution of these bodies, it was impossible for him to carry his speculations further. In the light of modern discovery we may perceive, however, that the assimilation of the comets into the nebulous matter, foreseen by Laplace, will be much more rapidly expedited, and that, notwithstanding the augmentation of temperature produced by friction, a still more considerable evolution of heat will result from the chemical union of the two. We cannot pretend to explain the exact chemical effects produced by the impact owing to our ignorance of some of the substances themselves; but, in any case, an enormous development of heat is certain to result; and whether the compound thus formed assumes the liquid or retains the solid form, it will certainly be of greater specific gravity than the rest of the nebula, of which it may now be said to form a part, and the revolution around the centre of gravity of the mass will be conducted precisely as indicated by Laplace. Those familiar with the extraordinary convolutions of many of the nebulæ will not fail to see how easily many such appearances may be explained, by imagining a long stream of meteoric bodies in the track of a comet pouring into the nebulous matter, and being retarded and absorbed

* Except as combined with silicon.

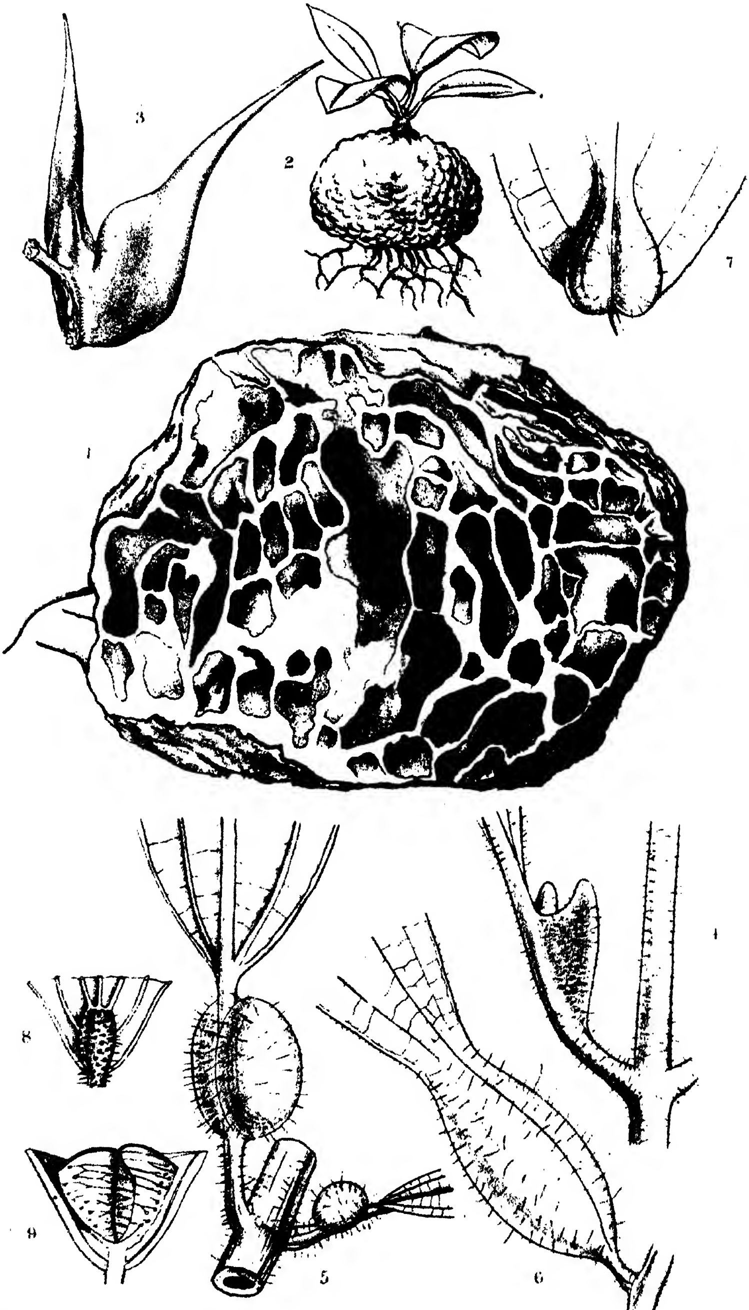
in their passage through it. There is good reason to suppose that the product of chemical union assumes generally the liquid rather than the gaseous form, since it has frequently been noted that a faint continuous spectrum may be discerned along with that of the bright gaseous lines in many nebulæ, and which is not confined to any particular portion of them.

We may now pretty clearly depict the condition of a nebula according to this hypothesis, when after the lapse of many ages a large number of comets and accompanying meteor-streams have been absorbed into its substance. It will consist of a greater or less residue of the original gaseous constituents, which, for reasons well known to spectroscopists, will still continue to yield most conspicuously the characteristic bright line spectrum, and dispersed throughout the mass an immense number of liquid nuclei, all tending towards the common centre of gravity in spiral orbits, the centre being occupied by a brilliant white-hot liquid mass. The temperature of such a nebula will be much higher than of one less developed—a fact which will tend to keep the density of the gaseous constituents at nearly the same level, in spite of the increased gravitational tendency to condensation near the centre. We may even conceive that this intense heat might be sufficient to render gaseous the liquid nuclei when a numerously bright-lined spectrum should make its appearance, but it would then be necessary to assume that the faintness of the spectrum would make it difficult to distinguish the difference between this and one truly continuous. We may, on the contrary, imagine the well-developed nebula to become a compact liquid mass, in this case also yielding a continuous spectrum. Nor does it seem unlikely that a considerable number of bodies in this latter state of existence may actually be discovered in the heavens. Many nebulæ, after having resisted the utmost efforts of astronomers, armed with the largest telescopes, to class them among the clusters of stars, have equally refused to be entered in the list of true nebulæ by yielding the discontinuous spectrum, and whose real condition remains, therefore, for the present an enigma. Of the two suppositions the second appears to me to be the most probable; yet if it be accepted, it will be necessary to reconstruct the nebular hypothesis, if it can still be maintained under the altered circumstances. There are, however, some facts which tend strongly to show that the first suggestion is the more correct one, or, in some cases at least, more closely approximates to the true condition of things. It is well known that the great nebula in Andromeda—one of those which defy alike the powers of the telescope and spectroscope—presents a very anomalous spectrum. Though apparently continuous, some portions of the red and orange are altogether wanting, and the more refrangible portion consists of a mottled band

with uneven gradations of intensity. This is very much what would be expected if the spectrum were really one of numerous bright lines, nor is it a singular instance. Several other nebulæ have given rise to strong suspicions of a similar constitution; and no theory, so far as I am aware, has hitherto been advanced in explanation of these appearances. I need not point out that, if this supposition is correct, a state of things arises in which the nebular hypothesis in its later form will again apply, with the addition only that the gases of the nebulæ are in a much more complicated condition than was formerly supposed to be the case.

It is to be remarked, that the number of comets which would be attracted to a nebula would increase in proportion as its mass increased with each succeeding capture, so that its development would proceed at an accelerated rate until a certain point was reached, when comparatively little of the gaseous elements remained. The comets would then describe their orbits around the newly-formed sun, and would leave only their smaller or outlying meteorites to swell its mass. But even these would greatly tend to compensate for the dissipation of heat by radiation, and would much retard the cooling process—a state of things that will continue to exist even in a perfectly formed system such as our own. I am thus led to regard the meteoric theory of the supply of solar heat as a part of the modified nebular hypothesis which I have suggested. If our sun is a nebulous star, surrounded by a far-extending atmosphere, in which are revolving a large number of meteoric bodies, visible possibly to us as the Zodiacal Light, the materials for keeping up a constant or nearly constant temperature for a considerable length of time are at hand, and every succeeding comet will add some to the number of those meteors which, unlike it, are unable to make their final escape, and pursue their orbits with scarcely diminished velocity. The smaller meteors in a stream, as presenting relatively a larger surface, will be more retarded than the larger, and will more rapidly fall upon the solar surface—so rapidly, indeed, that it does not seem unlikely that the universally held belief in the increased solar heat during years noted for large comets may have a sound foundation. Such a possibility is sufficient to invest the movements of comets with great practical interest, and the various circumstances producing the increased heat of such seasons must give rise to important investigations. Thus we should come to look upon the nearness of approach of a comet in perihelion as an essential element in such a discussion, and perhaps also the material composition of the comet itself. It has been suggested, with much show of reason, that the larger and nearer planets when in perihelion simultaneously have a considerable effect upon the solar surface by producing spots, &c., and these again, in

determining the amount of heat radiated from the sun; may we not therefore expect that the arrival in perihelion of a comet from most remote regions, which, if of smaller mass, often approaches the sun much more nearly than they, may also produce a marked effect on the state of the solar atmosphere? Although the 11-year period of solar spot frequency is too well marked to admit of any question, there is already much evidence to prove that there exists many minor disturbances, secondary maxima and minima of solar activity, which remain to be explained, and which may possibly be due to the occasional and irregular approaches of comets. It is certain that the solution of no question can be of more service to the advancement of science than that of the real practical utility of comets in the economy of the universe. Speculation on this point has already been too long neglected, and unless it is carried on now as far and as correctly as the state of modern science allows, it is certain that it will mask some other results and hinder progress. Surely none can believe that these bodies are mere *ignes-fatui*, coming and going, without being of any service to us or to other systems; and although much mystery has always hung about them and still baffles our researches, perhaps the best way of attaining to the solution of it is by searching for some purpose that they may subserve. Without attempting altogether to set up the nebular hypothesis in as favourable a light as before, the above remarks and speculations may serve to indicate the position in which it stands at present, and the broader basis on which in future the question must be argued. A certain degree of unity of design seems to result from these theories, which is consonant with the order of nature. Every known body in the universe appears to have an important and appropriate function to perform in the development or maintenance of systems like our own—a function that is constant in all conceivable states of existence of those systems; and while my speculations do not contradict the various theories of others, they show a tendency to unite them into one consistent whole. Perhaps the most distinctive feature of these remarks is, that the effects I speak of must actually take place, whether or not they have the importance here attached to them. No one will deny that the nebula and the comet will constantly come into contact; and were we acquainted with all the materials so meeting, it would be a comparatively simple problem for the chemist to determine what compounds would result, and for the physicist to show in what state, gaseous or otherwise, they would afterwards remain. Both these questions require to be answered satisfactorily before it is possible to declare whether the celebrated hypothesis of Laplace is or is not the true key to the solution of the formation and history of the Solar System; and for these answers, at the present, it waits.



D. Blair del et lith.

Ant supporting Plants.

ANT-SUPPORTING PLANTS.

By JAMES BRITTEN, F.L.S.,

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[PLATE CXVIII.]

THE relations between the animal and vegetable worlds, and the mutual dependence of one upon the other, offer some of the most interesting problems in natural science. The subject is one which has attracted special attention of late years, and the numerous observations of competent and trustworthy persons have rendered us familiar with many striking illustrations of it. The absolute dependence of certain plants upon particular insects for their fertilisation has been amply demonstrated; and it is now shown that insects may, in certain cases, serve the requirements of plants in another way, by supplying them with food. And this dependence extends more widely than might at first sight appear. Mr. Darwin gives an instance of this when speaking of the fertilisation of the red clover by the visits of the humble-bee. "The number of humble-bees in any district depends in a great degree on the number of field-mice, which destroy their combs and nests; . . . the number of mice is largely dependent, as every one knows, on the number of cats. . . . . Hence, it is quite credible that the presence of a feline animal in large numbers in a district might determine, through the intervention first of mice and then of bees, the frequency of certain flowers in that district."*

It is not, however, only as fertilisers or as food-suppliers that insects are connected with plants. Botanists are well acquainted with the fact that certain trees and plants offer homes to various species of ants; but this is not very generally known, and, so far as I am aware, no attempt has been made to bring together what has been recorded on the subject in scattered papers, or to collect the references, often merely incidental,

* "Origin of Species," ed. i. p. 74.

which have been made to the various ant-tenanted plants. I have for some time been collecting notes upon this subject, and have published a short paper upon one or two points connected with it.* Since then, however, so much additional material has come under my notice, that a brief *résumé* of the whole matter may be of some interest.

At first sight there might appear to be little remarkable in the residence of insects in trees. Many insects, of course, pass a large portion of their life in this situation; but in the instances to which I am about to refer, it would appear that the whole existence of the ants is passed in these vegetable homes; or rather, that when the ants have once taken up their abode in them, a colony is formed, which is only dispersed by the destruction of the tree. Not only is a dwelling-place found, but in some instances a means of support as well; and all this not only without injury, but even with absolute benefit to the tenanted plant.

These ant-homes are found not only in the hollow trunks of certain trees, where their presence would be less remarkable, but also in tubers, leaves, and thorns. I shall consider each of these separately, commencing with the tubers, the special adaptation of which to the requirements of the ants is truly wonderful.

By far the most striking instance of this is given by *Myrmecodia tuberosa*, to the very existence of which it would appear essential that its tuber should be tenanted by these insects. Rumpf, in the "Herbarium Amboinense," published in 1750, appears to have been the first to figure and describe this plant, under the name of *Nidus germinans formicarum rubrarum*, which he terms "mirum prodigium naturæ." He seems to have been uncertain whether the whole was a vegetable, or whether the tuber was an ant's nest from which the plant sprung: he says it is to be regarded as a zoophyte among vegetables! His account does not seem to have attracted any attention until about 1825, when the plant was described by Dr. Jack † as a genus of *Rubiaceæ*, under the name it now bears. It presents the form of a large irregular tuber, growing on the branches of old trees; from this spring a few thick fleshy stems, having a small number of smooth, leathery, oblong leaves crowded together at their summits. The small white sessile flowers are situated at the base of the petioles, and are almost concealed by the large persistent stipules. The tuber is tenanted by small and very fierce red ants, which rush out upon the intruder if their dwelling is attacked. The way in

* "Field," Feb. 7, 1874. † "Trans. Linn. Soc.," xiv. 122.

which these ants take possession of the *Myrmecodia*, and the intimate relation which exists between the plant and the insect, are thus referred to in Professor Caruel's recent paper upon the genus.* The account is quoted from a manuscript note by Dr. Beccari,† who collected the plant in Borneo:—

"I have carefully followed the development of this tuber, having been able to observe the young plants in all stages of growth from the period of germination. The seed is surrounded by a viscid pulp, resembling that of our mistletoe, which readily attaches itself to the branches of the trees upon which it falls. Its dissemination is probably caused by means of the birds which eat the fruit, the undigested seed passing through them and adhering to the branches. The seed soon germinates and unfolds its cotyledons, especially if it has fallen in an opening of a branch where lichens have collected, or if it be placed in mould; the stem developes itself to the length of from three to six millimetres, widening towards the base, acquiring a somewhat conical shape, with the two cotyledons at its apex. In this condition it remains until a particular species of ant burrows a small lateral cavity at the base of the stem; if this does not happen, the stem does not develope itself, and the plant dies. The wound caused by the bite of the ant determines a great development of cellular tissue, in the same way as the sting of the cynips causes the galls on the oak. The tuber now enlarges and the stem developes; the ants soon find sufficient space for forming a colony, and excavate galleries in the interior of the tuber in all directions, thus making for themselves a living habitation—a circumstance which is necessary to the existence of the plant. The plant could not live or even arrive at maturity unless the ants contributed to the formation of the organ which must be the source from which it derives its support, while in all probability the ants could not exist or propagate themselves unless they had discovered this mode of constructing so ingenious an habitation. The fleshy substance of this formicarium is formed of cellular tissue; the channels and galleries with which it is perforated have their entrance near the lower part of the tuber."

The genus *Myrmecodia* was formerly regarded as exclusively Malayan; but it is represented in Java by another species (or perhaps a form of *M. tuberosa*); and fine Australian specimens which perhaps belong to a new and undescribed species, have been recently received at Kew from Mr. Hill, of Brisbane. They greatly resemble a wasp's nest in external appearance, being of

* "Nuovo Giornale Botanico Italiano," iv. 170—176 (1872).

† This author has since described a new species from Celebes under the name of *M. selebica* in "Nuovo Giornale Botanico Italiano," vi. 195 (1874). It is intermediate between *Myrmecodia* and *Hydnophytum*.

a slaty-gray colour; and the galleries with which they are intersected in all directions are lined by the ants with a thin papery material.

The allied genus *Hydnophytum*, which differs from *Myrmecodia* in having a smooth tuber and small deciduous stipules, was also figured and described by Rumpf (as *Nidus germinans formicarum nigrarum*), and named and redescribed by Jack at the same time as *Myrmecodia*. In the structure of the tuber and its mode of use by the ants, it seems very similar to *Myrmecodia*, only that the best known species, *H. formicarum*, is inhabited not by red but by black ants. Three or four species are described, natives of Tropical Australia, the Fiji Islands, and the Indian Archipelago.

Passing now to those trees, the trunks and branches of which are used as habitations by ants, the most remarkable are those belonging to the South American genus *Triplaris*, all or nearly all the species of which are described by Meisner in Decandolle's Prodromus as "arbores ramulis fistulosis formicis hospitium præbentibus." Aublet, in his "Histoire des Plantes de la Guiane Françoise," published in 1775, figures and describes a species (doubtfully referred by Meisner to *T. surinamensis*, Cham.) under the name of *T. americana*, of which he says: "Ants are found in abundance in the interior of the trunk, branches, and twigs of this tree, in such a manner that when one strikes or cuts it, one is soon quite covered and acutely tormented by them, an accident which I myself have experienced. The only means by which one can get rid of them is to plunge oneself in water." *Triplaris* is a genus of *Polygonaceæ*, forming with *Ruprechtia* and the monotypic genus *Podopterus* the sub-tribe *Triplarideæ*; it is characterised by the remarkable shuttlecock-like appearance of the fruit, an appearance caused by the three outer lobes of the perianth growing out into erect membranous wings, and reminding one very forcibly of the fruits of Dipterocarps. The most detailed account of the ant which infests these trees is that given by Weddell,* who says:—

"The trunk, the branches, and even the smallest branchlets of the species of this genus are hollow, and serve as habitation to a peculiar species of ant, which gives off when excited a somewhat agreeable scent, resembling that of the *Cicindeleæ*. If one happens to touch the trunk of a *Triplaris* accidentally, especially if it is shaken, the ants rush out by hundreds from the interior of the tree through the small canals by which the medullary canal communicates with the exterior, and if escape is not made as quickly as possible one is covered with these

* "Ann. Sc. Nat. (Bot.)," 3rd series, xiii. 262—267.

dangerous guests, the bite of which is much more painful in proportion than the stings of any other insect with which I am acquainted. It is a singular thing that, at whatever stage of their existence one examines the *Triplaris* in the forests, one is always certain to encounter these ants. It is still more curious that in *Ruprechtia*, which some authors unite with *Triplaris*, they are never met with. I do not think that this insect has ever been observed in other conditions than those which I have noted; its linear form is especially adapted to its mode of life. I have had occasion to examine it and indeed to suffer from its attacks in many parts of Brazil, in Bolivia, and in Peru, and it has everywhere appeared to me identical. Many travellers have already recorded a portion of the facts in question, and have referred the ant of the *Triplaris* to Latreille's genus *Myrmica*, but I am not aware that it has received a specific name; that of *triplarina* may be applied to it. It is usually of a clear brown; its length is six or seven millimetres, and its breadth one millimetre; the abdomen is cylindrical and a little attenuated towards its lower extremity, which is hairy." The ants swarm especially in two or three species, notably in *T. nolitangere* (so named by Weddell on this account), which is called Formigueira by the Brazilians, *T. Bonplandiana*, and *T. Schomburgkiana*. This last species is described at length by Dr. Schomburghk,* but his description adds nothing of importance to what has been already cited; he remarks that the different tribes of Indians in Guiana call it by names which signify "the ant-tree."

The well-known Trumpet-tree (*Cecropia peltata*) is also ant-inhabited, a fact to which Mr. Belt directs attention in his interesting "Naturalist in Nicaragua." As in *Triplaris*, the trunk is hollow, and provided within with partitions answering to the position of the leaves on the outside, and it is in the spaces between these partitions that the ants congregate. They "gain access by making a hole from the outside, and then burrow through the partitions, thus getting the run of the whole stem. They do not obtain their food directly from the tree, but keep brown scale-insects (*Coccidæ*) in the cells, which suck the juices from the tree, and secrete a honey-like fluid that exudes from a pore on the back, and is lapped up by the ants. In one cell eggs will be found, in another grubs, and in a third pupæ, all lying loosely. In another cell, by itself, a queen ant will be found, surrounded by walls made of a brown waxy-looking substance, along with about a dozen *coccidæ*, to supply her with food. . . . If the tree be shaken, the ants rush out in myriads, and search about for the molester. . . . I have cut into some

* "Annals and Magazine of Natural History," i. 264.

dozens of *Cecropia* trees, and never could find one that was not tenanted by ants. I noticed three different species, all, as far as I know, confined to the *Cecropia*, and all farming scale-insects. . . . There is never more than one species of ant in the same tree."

A shrub of another order of plants was described by Aublet, in the work already mentioned, as affording a home for ants. This is the Gentianaceous genus *Tachia*, a name which Schreber changed to *Myrmecia*, although this latter is discarded by all writers, for the older one, in accordance with the laws of botanical nomenclature. "The trunk and branches," says Aublet, "which are hollow, serve as a retreat for the ants; it is on this account that this shrub is named by the Galipis Tachi, which in their language signifies ants' nest." It is worthy of note that from the axils of the leaves, when a flower is not produced, there exudes a drop of transparent yellow resin: it is probable that this is employed in some way by the ants, as we shall see to be the case with an excretion of the *Acacia* which they inhabit. An orchid, *Schomburgkia tibicinis*, a native of Honduras, is also ant-tenanted. The long hollow pseudo-bulbs have a small hole at their base through which the ants enter; and so thoroughly take possession of the plant, that Mr. Skinner, who discovered it, was almost prevented from collecting specimens by the stings of the swarms which rushed out upon him when he touched it. It is probably to some orchidaceous plant that Mr. Bates refers when he says that the formicarium of the Brazilian *Crematogaster limatus* is "in perforated glandular swellings in the suspended air-roots of a parasitic plant." M. Beccari, in Professor Caruel's previously quoted paper, says: "I have observed a species of *Clerodendron* which grows at Savannah which has the upper internodes swollen, the centre being hollow, and furnished with an aperture through which the ants go in and out." In the South American section *Physoclada*, of the Boraginaceous genus *Cordia*, the branches are swollen at the bases of the petioles of the upper leaves: these swellings are hollow, and in *C. nodosa* (and probably in the other species of the section) are tenanted by ants, whence it is called by the natives of Para *Pao de Formige.*

In certain species of the genus *Acacia* the stipules are converted into large thorns, which are broad and hollow at the base. These species were formerly grouped together under the name of *A.* (or *Mimosa*) *cornigera*, and have long been known to shelter ants. Thus Martyn, in his edition of Miller's "Gardeners' Dictionary," says: "The spines are subaxillary and connate at the base, resembling the horns of oxen; they are brown, shining, hollow, and the longest are more than five inches in length; they are all over the tree, and when the pods

are ripe and the leaves are falling they have a singular appearance. A sort of ant lodges in these thorns in immense quantities, and if the tree be shaken ever so little, they fall down like a shower of rain and attack the passenger." The *Mimosa cornigera* of older botanists is now referred to various Acacias, such as *A. cochliantha*, *A. macrantha*, *A. sphærostachya*, *A. spadigera*, and others, all characterised by these large hollow thorns. Mr. Belt, in his already-quoted volume, has given so many interesting particulars of the relations existing between the ants and one of these species, which he calls the "bull's-horn thorn," that I shall make no apology for quoting some of them, especially as they differ in various points from any other account. "These thorns," he says, "are hollow, and are tenanted by ants that make a small hole for their entrance and exit near one end of the thorn, and also burrow through the partition that separates the two horns, so that the one entrance serves for both. Here they rear their young, and in the wet season every one of the thorns is tenanted, and hundreds of ants are to be seen running about, especially over the young leaves. If one of these be touched, or a branch shaken, the little ants (*Pseudomyrma bicolor*, Guer.) swarm out from the hollow thorns, and attack the aggressor with jaws and sting. They sting severely, raising a little white lump that does not disappear in less than twenty-four hours. These ants form a most efficient standing army for the plant, which prevents not only the mammalia from browsing on the leaves, but delivers it from the attacks of a much more dangerous enemy—the leaf-cutting ants. For these services the ants are not only securely housed by the plant, but are provided with a bountiful supply of food; and to secure their attendance at the right time and place, this food is so arranged and distributed as to effect that object with wonderful perfection. The leaves are bipinnate; at the base of each pair of leaflets, on the mid-rib, is a crater-formed gland, which, when the leaves are young, secretes a honey-like liquid. Of this the ants are very fond, and they are constantly running about from one gland to the other to sip up the honey as it is secreted. But this is not all; there is a still more wonderful provision of more solid food. At the end of each of the small divisions of the compound leaflet there is, when the leaf first unfolds, a little yellow fruit-like body, united by a point at its base to the end of the pinnule. Examined through a microscope, this little appendage looks like a golden pear. When the leaf first unfolds the little pears are not quite ripe, and the ants are continually employed going from one to another examining them. When an ant finds one sufficiently advanced it bites the small point of attachment; then, bending down the fruit-like body, it breaks it off and bears it away in

triumph to the nest. All the fruit-like bodies do not ripen at once, but successively, so that the ants are kept about the young leaf for some time after it unfolds. Thus the young leaf is always guarded by the ants." This reciprocity of services between the insects and the plant is very remarkable. Mr. Belt gives other details on the subject, for which reference must be made to his work. He adds that the *Acacia* is sometimes, although less frequently, tenanted by another ant, a species of *Crematogaster*, which occupies the whole tree to the exclusion of the *Pseudomyrma*, and makes its entrances to the thorns near the centre of one of each pair, and not near the end. Although the thorns are so hollowed out that only the hardened shell remains, the tree receives no injury from the ants, and the thorns increase in size in consequence of their visits. Mr. Belt says that plants of the *Acacia* raised in his garden were not touched by the ants, and that the thorns turned yellow, and dried up into dead but persistent prickles; this, however, may have been due to an unsuitability of habitat. Mr. F. Smith, of the British Museum, has directed my attention to his description* of a species of *Pseudomyrma* (*P. modesta*), forwarded to him by Mr. Stretch, from Panama. He gives the following account of the nest of this ant: "It consists of the large hollow thorns or spines of a species of *Acacia*. The spines are three inches long, tapering to a point from a broad base. The ants gnaw a small hole towards the point of the spine; the broad base then forms an admirable domicile for their young brood. There are no cells or divisions of any kind for the reception of eggs or larva. The number of pupæ found in one nest was seventy-nine, and about twenty mature ants, all workers. These ants sting very violently."

The leaf-dwellings of ants are found chiefly in some closely-allied genera of *Melastomaceæ*, all natives of South America. It is worthy of remark that, with the exception of *Myrmecodia* and *Hydnophytum*, which are in almost every respect very different from the other ant-inhabited plants, all the genera which have come under my notice in connection with this subject are South American, and I find no instance of similar phenomena either in Europe or Africa. In these *Melastomaceæ*, belonging to the genera *Tococa*, *Calophysa*, *Maieta*, *Microphysca*, and *Myrmidone*, it is usually the petiole which is adapted as a residence for the ants. The description given by Aublet † of the means by which this is effected in *Tococa guianensis* will apply, with slight modifications, to the other genera. "The leaves," he says, "are attached to the stems by

* "Trans. Entom. Soc.," 3rd series, vol i. part 1.

† "Plantes de Guiane," i. 439.

a small petiole, furnished with hairs, which is hollowed out into a groove in its upper surface, and is convex below; the two sides of which swell and enlarge, forming a double heart-shaped bladder. This bladder corresponds with two holes, which are placed on the under side of the base of each leaf, between the two intermediate nerves. It is by these two holes that the ants enter and go out of both divisions of this bladder; and as the stems are hollow, the ants enter them by different openings which they make in them. It is to this that the plant owes the name *nid de fourmis*, which has been bestowed upon it by some of the natives, for it is always, so to speak, covered with these insects." This singular arrangement has not escaped the notice of Mr. Belt, who observed similar *Melastomaceæ* at Pará and in Northern Brazil. He says: "Every pouch was occupied by a nest of small black ants; and if the leaf was shaken ever so little, they would rush out and scour all over it in search of the aggressor. I must have tested some hundreds of leaves, and never shook one without the ants coming out, excepting one sickly-looking plant at Pará. In many of the pouches I noticed the eggs and young ants, and in some I saw a few dark-coloured *coccidæ* or *aphides*; but my attention had not been at that time directed to the latter as supplying ants with food, and I did not examine a sufficient number of pouches to determine whether they were constant occupants of the nests or not; but my experience since with the *Cecropia* trees would lead me to expect that they were. If so, we have an instance of two insects and a plant living together, and all benefited by the companionship. The leaves of the plant are guarded by the ants; the ants are provided with houses by the plant, and food by the *coccidæ* or *aphides*; and the latter are effectually protected by the ants in their common habitation." The structure of the bladder in the other Melastomaceous genera named differs but slightly from that of *Tococa guianensis*; in some it forms part of the leaf, while in others it is somewhat separated from it; it varies in form between round, oblong, and heart-shaped, as may be seen from the accompanying figures. Mr. Trail, who is at present investigating this subject, writes from Santarem to Dr. Hooker (who has kindly lent me his letter), that at least three species of ant inhabit a Melastomaceous plant, which he believes to be *Myrmidone formicaria.* He says: "The leaves of the *Myrmidone* frequently bear hardly any trace of the bullæ, even on the same twig on which occur largely-developed bullæ; ants are usually to be found in them, but not by any means constantly, while sometimes they are taken possession of by solitary bees and wasps." Of another Melastomacea he writes: "Of it I have only as yet seen two bushes; on one of them every bulla was tenanted by ants; on the other not

one was so occupied, though the bulliferous leaves bore numerous small ants' nests on their under surface, commonly just over the orifices." It is to be hoped that Mr. Trail's further researches will add additional information to that which we at present possess on this interesting subject. The ants inhabiting the *Melastomaceæ* appear to be quite as pugnacious as those of other plants. Mr. Spruce, in a manuscript note in the Kew Herbarium, speaks of *Myrmidone* as tenanted by "a small fiery ant whose sting I shall long remember."

I do not know that instances of leaf-habitation have been recorded in any other order of plants; but I believe an instance may be found in a South American Rubiaceous plant, now referred to *Remijia*, but distributed by Spruce under the name of *Ladenbergia* (?) *physophora*. This plant has hollow bladders at the base of the petiole, which, judging from their analogy with those of the *Melastomaceæ*, may be tenanted by ants; the stems also are hollow.

This is, so far as I am aware, a summary of what has been hitherto recorded upon this curious and interesting subject; and although I have brought forward no new facts, I am not without hope that, by directing attention to the matter, further information may be obtained. It is almost certain that many more plants will be found to offer a home to ants. I have been much struck with the ventricose hollow swellings which almost uniformly appear on the stems of *Hyptis Salzmanni*, *H. calophylla*, and other allied South American species and which suggest the probability that these also may be inhabited by ants; but this is only an hypothesis.

The following is a classified list of the plants which I have mentioned, showing the part which is affected in each :—

LEGUMINOSÆ.—*Acacia*, various species (thorns).

(1.) MELASTOMACEÆ.—*Tococa*, *Calophysa*, *Microphysa*, *Myrmidone*, and *Maieta*, various spp. (petioles and leaf bases).

(2.) RUBIACEÆ.—*Myrmecodia* and *Hydnophytum* (tubers); (?) *Remijia* sp. (petioles).

GENTIANACEÆ.—*Tachia guianensis* (stems).

BORAGINACEÆ.—*Cordia nodosa* (bases of petioles).

VERBENACEÆ.—*Clerodendron* sp. (internodes).

POLYGONACEÆ.—*Triplaris* spp. (trunks and branches).

ARTOCARPACEÆ.—*Cecropia peltata* (trunks and branches).

ORCHIDACEÆ.—*Schomburgkia tibicinis* (pseudo-bulbs).

EXPLANATION OF PLATE CXVIII.

FIG. 1. Section of tuber of *Myrmecodia*, from a specimen in the Kew Museum, showing the galleries formed by the ants.

FIG. 2. Small plant of *Hydnophytum formicarum*, from a specimen in the British Museum.

FIG. 3. Thorn of *Acacia* sp., from a specimen lent by F. Smith, Esq.

FIG. 4. Petiole of *Tococa macrophysca*, Spruce, from the British Museum Herbarium.

FIG. 5. Petiole of *Tococa guianensis*, Aubl., from the British Museum Herbarium.

FIG. 6. Leaf-base of *Tococa bullifera*, Mart. and Schrenk, from the British Museum Herbarium.

FIG. 7. Leaf-base of *Tococa macrosperma*, Mart., from Martius' "Nova Genera et Species Plantarum."

FIG. 8. Leaf-base of *Maieta hypophysca*, Mart. (back view), from Martius' "Nova Genera et Species Plantarum."

FIG. 9. The same, opened, from Martius' "Nova Genera et Species Plantarum."

GUNPOWDER: ITS MANUFACTURE AND CONVEYANCE.

By A. HILLIARD ATTERIDGE.

A LITTLE before five o'clock on the morning of the second of last October, a train of four barges was being towed by a steamer along the Regent's Canal, in the north-western district of London. The second of these barges was laden with a miscellaneous cargo, packed in such a manner, and containing such elements, that the barge was really a very efficient kind of torpedo. In her hold there were about five tons of gunpowder and a quantity of benzoline in kegs. This benzoline may be described as a very volatile species of petroleum. At ordinary temperatures it gives off a highly inflammable vapour, and this, when mingled with the air in certain proportions, becomes explosive—the explosion running through it at the rate of about two feet per second when it is confined in a tube. In the case of the barge on the Regent's Canal, the cargo was closely covered with a tarpaulin, to protect it from the weather. From the moment, then, that this covering was put on by the bargemen, the vapour given off by the benzoline began to accumulate in the hold, and mingle with the air confined in the spaces between the various packages of the cargo. Thus the hold gradually became filled with a fiery explosive atmosphere, and all that was wanted to produce an explosion was contact with flame. In the little cabin, at the stem of the barge, a fire was burning, and there was an aperture in the bulkhead, or partition, which divided the cabin from the hold. Through this the benzoline vapour entered the cabin, and the air in it was soon as vitiated as that under the tarpaulin in the hold. It was ignited by the fire; the explosion, beginning in the cabin, ran forward in a few seconds to the bow, and fired the gunpowder stowed there.

Everyone knows what followed. Half London was awakened by the report, which was heard for miles around—to the northward as far as Finchley and Enfield, to the southward as far as

Blackheath and Woolwich. Within a radius of from half-a-mile to a mile from the scene of the explosion houses were wrecked, windows blown in, doors burst open, ceilings shaken down, ornaments and furniture dashed to pieces. A massive bridge over the canal was destroyed, for hundreds of yards its embankment was displaced, and the house which stood nearest to it was so shaken that it had to be pulled down next day. The effect was more like that of a severe shock of an earthquake than anything else. Fortunately no lives were lost except those of the crew of the barge, but the destruction of valuable property was enormous.

Much alarm has been caused not only in London but throughout the kingdom by this explosion in the heart of the metropolis, and it will have a useful effect in calling attention to the dangerous character of a material so largely employed as gunpowder, and the consequent necessity of carefully regulating its manufacture, storage, and transport, and seeing that these regulations are strictly enforced; for no matter how perfect our precautions may be in theory, they are worse than useless if we cannot secure their practical efficiency. Without this, their only result must be to lull us into a false security. Gunpowder, and its manufacture and transport, are now subjects in which nearly everyone is interested; and we purpose to devote the following pages to an account of the nature and action of this explosive, its manufacture, and the principles involved in it, and, finally, its transport, and the precautions necessary for our security against explosions like that of last October. We shall describe the process of manufacture in use at the Government mills, as these are probably the most perfect and efficient in the kingdom.

Fifteen miles to the north-east of London, between the sluggish stream of the River Lea and the northern heights of Epping Forest, stands the little village of Waltham, famous for its old abbey, founded by the last Saxon King of England, and destined to be his tomb after the fatal field of Hastings. On both sides of the high-road beyond the village extends a wide tract of flat alluvial ground, traversed by the branches of the Lea, and rich in plantations of willow and alder, with here and there stately rows of poplars. A tall chimney shaft, the roofs of scattered buildings, and a range of houses near the road, indicate that these well-planted fields are the site of the Royal Gunpowder Factory.

The Waltham Abbey Mills are probably the oldest in Great Britain. They must have been established about the middle of the sixteenth century, for we know that before that time nearly all the powder used in England was imported from the Continent. But in 1561 we hear of John Thomworth, of Waltham,

buying, as agent for Queen Elizabeth, saltpetre, sulphur, and staves for making barrels. In the following century the parish register shows entries of deaths resulting from explosions at the mills; and Fuller, who was rector of Waltham, alludes in one of his works to the dangers of the manufacture, remarking that the mills were blown up five times during the seven years of his residence in the parish. The only wonder is that explosions were not far more frequent in the old factories, where the elaborate precautions now adopted were utterly unknown. Powder was allowed to accumulate in heaps on the floor, spirits of wine was used instead of water to moisten the ingredients, under the impression that it made better and stronger powder, and the drying process was effected by heating the powder on metal plates over a fire without any means of regulating the temperature. Finally, all the workrooms were close together, and often under a single roof, so that if the powder in one room exploded, that in the rest would follow, like a boy's train of crackers.

It was in 1787 that Government bought the Waltham Mills from the last private proprietor, Mr. John Walton, supposed by some to have been a descendant of the family of old Izaak. Major (afterwards Sir William) Congreve was the first superintendent. Horse and water power only were employed, most of the machinery was of wood, and the incorporating mills were, like mortar-mills at the present time, worked only by horses. Since then great improvements have been introduced into the manufacturing process; the factory has been widely extended, gun-metal and copper have been largely substituted for wood in the structure of the machines, refining-houses have been erected for purifying the saltpetre and sulphur, and retorts for preparing the charcoal. Machinery has been designed and erected for the preparation of the large cannon powder introduced of late years, and in the mills iron runners, driven by steam, have taken the place of the stone runners, drawn by old horses. A complete code of rules and precautions have been introduced, and every building protected by a system of lightning-conductors. The factory gives employment to about two hundred men, and can produce twenty-four thousand barrels of gunpowder in the year, and the powder is believed to be at once the best and cheapest made by any existing factory.

Before describing the process of its manufacture at Waltham, it may be as well to note a few facts on its composition and action. Gunpowder may be regarded as a solid, which, by ignition, can be very rapidly converted into a large volume of gas at a high temperature. It is this quality which constitutes it an explosive, for the sudden expansion is what we call explosion, though the name is sometimes given to the loud report which accompanies it, caused by the outrush of the gas gene-

rating sound-waves in the air. When the explosion occurs in a confined space, the weakest portion of the confining bodies gives way before it. In quarrying, the rocks are rent, as the gas from the blasting-powder forces them apart. In blowing down walls and gates, the mass of earth heaped on one side to form the "tamping" offers a greater resistance than the wood or stone on the other, and the wall or gate gives way. In firing a cannon, the loose shot offers less resistance than the solid coils of the gun, and it is driven out to a distance proportioned to the force of the charge. If there is any defect impairing the strength of the cannon, or if the shot wedges in the bore, the gun bursts; for nothing we know of can resist the force of the gas. Recent experiments prove that this force, exerted in closed vessels unrelieved by expansion, is equal to a pressure of about forty tons on the square inch.

Of the three materials of which gunpowder consists—sulphur, charcoal, and saltpetre—only the two last are, strictly speaking, essential to it. The gas is actually generated from the charcoal and saltpetre, therefore a mixture of these only will explode. On ignition the charcoal decomposes the saltpetre, its combustion being supported by the oxygen of the latter, in combination with which it forms carbonic acid gas, and this, mixed with the nitrogen from the saltpetre, is the *gas* which produces the useful effect. But when gunpowder is thus made with saltpetre and charcoal only, the power developed by the explosion is comparatively trifling, and sulphur has to be added to increase it to such an extent as to make it really efficient. The sulphur acts in two ways to this end. In the first place, it ignites at a lower temperature than either charcoal or saltpetre, and its combustion accelerates both the decomposition of the saltpetre and the generation of gas, by combining with the potassium of the saltpetre and liberating the oxygen. Then, by heating the carbonic acid and nitrogen, it considerably increases their volume, and, consequently, their explosive force. The flash, and smoke, and the fouling of the gun, are the result of the decomposition of the saltpetre, and consist of sulphates and carbonates of potassa, resulting from the combination of potassium with the sulphur and carbon. The substances thus formed, swept out into the air, become flame and smoke, or remain in the bore of the gun as fouling, and it is these solid substances that blacken the faces of men engaged in close conflict.

Thus we see that of the materials of gunpowder saltpetre is the most important. Both saltpetre and sulphur arrive in England in a rough state, mixed with various impurities. It is generally the practice in private factories to purchase these materials after they have been refined elsewhere; but at Waltham the refining process is carried on within the works. By

this means the materials are obtained of a uniform quality and perfectly pure. The saltpetre comes from various districts of India, chiefly from Bengal and Oude, where it is found mixed with the soil, and as an incrustation on the ground. In India it is boiled, and roughly crystallised by evaporation. When it is required for use in the Gunpowder Factory, it is purified by a process founded on the principle that hot water will receive in solution more of the saltpetre than of the impurities mingled with it. The saltpetre is boiled in water; the resulting solution is then filtered and allowed to cool in large vats, at the bottom of which the pure saltpetre is deposited in fine crystals. It is then washed, dried, and stored in bins, great care being taken that no sand or gritty particles are introduced, as they might cause an explosion when under pressure at subsequent stages of the manufacture, and the same precaution is taken with the sulphur and the charcoal. It is believed that many of the explosions which occur in private factories are caused by foreign substances being present in the materials.

The sulphur is all of the best quality, imported from Sicily. It is purified by a distilling process, which reduces it from its rough state to masses of handsome yellow crystals. It is then pulverised by being ground under iron runners, and sifted in a kind of revolving cylindrical sieve, called a "slope reel." The sulphur refining-house is, of the whole factory, the least pleasant portion for a visitor, the air being always tainted with the fumes of the sulphur, which are so strong as even to burn and destroy the leaves of the trees near the building. The management of the process is, however, by no means an unhealthy labour. The workman last employed at it died as a pensioner at the ripe old age of eighty, after having worked forty years in the refining-house.

The charcoal is all made on the spot, chiefly from wood imported from Holland and Germany. The alders and willows in the plantations of the factory furnish but an insignificant supply, probably not enough to make a dozen barrels in the year. They are grown for the most part to form screens around and between the houses, so as to diminish the danger resulting from a possible explosion. The wood employed is of three kinds—alder and willow, which are used for common powder, and black dogwood for fine rifle powder for the Snider and Martini-Henry. The latter wood is really a kind of buckthorn (*Rhamnus frangula*), of slow growth, and, consequently, close grain, which forms dense thickets in the forests of Germany, and is also found in the north of England and elsewhere. It is imported in bundles of slender rods about six feet long, and enormous quantities of these bundles may be seen stacked in the fields of the factory. There it is kept for at least three years, though

generally it is allowed to lie in store for a much longer time. Some wood has been kept for twenty years, protected from the weather by a roof of thatch, and is still perfectly sound. Strange to say, comparatively little dogwood is used in the powder factories of Germany, though it is quite certain that it supplies the best charcoal for the purpose.* The old plan for charring wood was to burn it in pits, and this is still the practice abroad, but for many years the charcoal at Waltham has been manufactured by sawing the wood into short lengths, and packing it into iron cylinders called "slips," which are placed on a small carriage, and run into a retort very like those used in gasworks. Here the slip is exposed to the flames for a period varying from two and a-half to three and a-half hours, the gas issuing from the wood in the process being utilised as fuel; and the superintendent of the work knows when the wood is completely charred, by the peculiar colour with which the combustion of the gas tinges the fire. As soon as this appears, the slip is withdrawn and cooled. The charcoal when taken out is ground in a machine like a colossal coffee-mill, and then, like the sulphur, sifted in a slope-reel.

The three ingredients are now ready for the regular process of manufacture to be commenced. Up to a certain point (the formation of the "press-cake") the process is the same for whatever purpose the gunpowder is intended, but at that point it divides into two branches, according as it is to be used for heavy guns or smaller weapons. We shall, therefore, first trace the various stages of the manufacture up to the press-house, and then explain the method of making the various kinds of gunpowder, and the objects desired to be obtained by these modifications.

The first process is that of simply mixing the ingredients. For this purpose the proper quantities of each are accurately weighed out, allowance being made for a certain amount of moisture in the saltpetre. The proportions vary in different countries, and according to the purpose for which the gunpowder is to be used. For English Government powder of every kind it is—saltpetre 75 parts, sulphur 10, charcoal 15, the sulphur being reduced almost to a minimum, as its chief use is only to ignite the charge and accelerate its action. In France

* M. Proust's experiments on charcoal, made from various woods, give the following results:—12 grains of charcoal of each wood, mixed with 60 grains of saltpetre and ignited, yielded the following proportions of gas in cubic inches: Dogwood, 80-84; willow, 76-78; alder, 74-75; filbert, 72; fir, 76; elm, 62; oak, 61-63. The importance of not overheating the wood is shown by the fact, that when the charcoal consisted of overheated willow, the yield of gas was only from 59-66 cubic inches.

and Prussia the quantity of sulphur is larger, the scale being saltpetre 75 and 12·5 parts each of sulphur and charcoal, while in Chinese powder the amount of sulphur is between 14 and 15. It is remarkable that in all countries the proportion of saltpetre remains about the same.

The ingredients, being weighed for a charge of 50 lbs., are poured into a "churn." This is a revolving drum, placed horizontally, and having within it an axis revolving in a different direction from the drum, and furnished with eight rows of projecting arms, or "flyers." So rapid is the action of this apparatus, that when the charge has been three minutes in the revolving churn the ingredients are thoroughly mixed together. It is then known as a "green charge," and is ready for the incorporating mills, the object of which, as the name indicates, is to incorporate the materials, or to make the mixture so intimate that a new substance is produced, namely, gunpowder.

The incorporating-houses at Waltham contain at present thirty-two separate mills. Each mill consists of a pair of runners, coupled together by a strong axle. This axle rests in the socket of an upright shaft, which, passing down through the mill-bed, is connected by bevel-wheels with a revolving horizontal shaft, driven by steam or water-power. The runners are either of black Derbyshire limestone or of iron, and weigh from three and a-half to four tons. Iron runners are now generally used, and their size varies from three and a-half to seven feet in diameter. The mill-bed, a large circular vat with a flat bottom and sloping sides, is of stone or metal, according to the material of the runners. On this bed 50 lbs. of the green charge is spread out and moistened with water, and the mill is then set going. The length of time required for the incorporation of the powder varies according to the use to which it is to be applied. Thus cannon powder is left under the mills for three hours; while for rifle powder, which requires a closer incorporation on account of its more rapid action, the time is five hours. The power of a gunpowder factory is measured by the number of pairs of runners it possesses, for as the law allows no more than 50 lbs. to be placed in any mill at one time, the amount which can be incorporated in a year is easily calculated. A pair of iron runners, driven by steam and working day and night, will incorporate in a year nearly 100,000 lbs. of cannon powder, or about half that quantity of rifle powder.

This part of the process is more dangerous than any other, and explosions in the incorporating-mills are very frequent. The houses are built of light planking, nailed on a strong framework, so as to diminish the force of the explosion by yielding easily before it. The men are forbidden to remain in them while the mill is in motion, and a very simple arrangement has

been devised for preventing an explosion from extending from one mill to another. A shaft runs horizontally through the upper part of the walls of each row of mill-houses. A shutter, balanced by a weight on the other side of the shaft, projects from it over each mill, and this shutter supports one side of a water-tank, the other resting on a pivot. Now, if an explosion takes place in any of the mills, the shutter above it will be blown up, turning the horizontal shaft, and raising all the shutters attached to it; so that the tanks, being left unsupported, turn over, and drench the contents of the mill-beds below.

On leaving the mill, the gunpowder is in the form of a soft cake, which easily breaks up into meal and dust. The old plan for making gunpowder, still followed in some places, was to moisten this mill-cake and force it through fine sieves, so as to break it into grains; but the moisture partly dissolved the saltpetre, and thus, to some extent, destroyed the previous incorporation, and the result was an inferior gunpowder, which, on account of the softness of the grains, often broke up into dust in transport. In the modern process, the mill-cake is first pressed in layers between plates of copper or gun-metal, to increase its hardness and density, and then made into grains of the required form by machinery. As a preparation for the press, the mill-cake is roughly broken down into meal and dust by being passed between grooved gun-metal rollers. It is then ready to be poured into the press-box.

This is a large box of gun-metal, lined with oak, and capable of holding about 800 lbs. of powder. The sides are hinged to facilitate unloading, and by means of a small crane it can be swung into or out of the hydraulic press. To be loaded it is turned on one side, a wooden cover placed on the top, and the uppermost side is turned back on its hinges. Then, by means of gun-metal racks, the plates are arranged in the box, with the proper intervals between them to produce a thick cake for cannon powder, or a thin one if rifle powder is to be made. The powder meal is then poured in between the plates, the racks withdrawn, the side closed and bolted down. It is then swung by the crane on to the table of the press, and the cover taken off. The press is an ordinary hydraulic one; the table which supports the box is placed on the head of the ram, and as it rises a block of oak fixed overhead enters the box, and presses the powder, the amount of the pressure being measured by the extent to which the block enters the box. The pumps which supply the press with water are fixed in an adjoining room, and worked by a water-wheel; and in order that the men may know when the pressing is complete without having to enter the press-room, a kind of catch and trigger is attached to

the side of the block, and as soon as the press-box has been forced up to the required point, the catch is liberated by coming in contact with it, and rings a bell in the pump-room. The pumps are then stopped, the ram falls by its own weight, and the box is unloaded, the gunpowder being taken out in large cakes the size of the metal plates, and as hard as slate. It is in the pressing of the gunpowder that the most serious explosions occur, for if by any chance the pressure becomes too severe, and the powder explodes in the box, its force is much greater than if it were ignited in the open air. Seven men were killed by an explosion in the press-house at Waltham Abbey in 1843, and by a similar accident on June 16, 1870, five were killed and seven injured.

The question of the density given to gunpowder by pressing and its effects is one which is only now being worked out. Formerly the density of the powder was roughly ascertained by weighing a cubic foot of it, and then its quality was tested by observing to what distance it would fire a shell from a mortar. These primitive methods are now superseded by a testing apparatus, which gives scientifically accurate results. The density is determined by reducing a small quantity of the powder to dust in a mortar, and then placing it in a glass globe provided with stopcocks, one of them connected with an air-pump, and the other with a tube dipping into a vessel of mercury. On exhausting the air, closing the first cock and opening the second, the mercury is forced into the globe, and completely fills it. It is then weighed in a delicate balance, and, its weight when filled with mercury only being known, it is easy to calculate the density of the gunpowder.

Its force is ascertained by observing the initial velocities which it will give to a shot fired from a cannon. These velocities are measured with Bashforth's Chronograph, as explained in a former article in the POPULAR SCIENCE REVIEW; * and with the Noble Chronoscope, the invention of Captain A. Noble, of the Elswick Works, by means of which we are enabled to ascertain what takes place in the bore of the gun on the explosion of the charge, and what is the velocity of the shot, not only in the whole length of its course within the gun, but also in each portion of that short distance, thus determining the velocity within very small limits both of time and space, and this with the most perfect accuracy.

It is difficult to describe the chronoscope without a diagram, but it is easy to indicate the general principles of its action in a few words, and this will be sufficient for our purpose. A gun

* "On the Striking Velocity of Shot." By W. Royston Pigott, M.D., P. S. R., Jan. 1871.

having been selected for the experiment, six or eight holes are drilled in one side of it, penetrating to the bore, at intervals along its length from the seat of the shot to the muzzle. Through each of these holes an insulated wire enters the gun, its lower extremity being in contact with but insulated from a sharp cutting edge, so arranged in the bore of the gun that the passage of the shot would force it down upon the wire and destroy the insulation. Each of the wires is connected with the secondary wire of an induction coil. The recording apparatus consists of a series of discs of polished silver, coated with lamp-black, and made to revolve simultaneously by the action of a falling weight and multiplying wheels at a very high velocity. One of these discs corresponds to each of the wires, the end of which is placed in a small discharger close to its circumference. On firing the charge the shot cuts the insulation of wire after wire in rapid succession, and as each is cut a current passes and a spark darts from the discharger to the edge of the revolving disc, striking off a speck of the lamp-black, and leaving the bright silver bare. Now, supposing the velocity of the circumference of the discs to be one thousand inches per second, and the mark of the electric spark on the second disc to be one inch farther on than that upon the first, this would show that the shot took the one-thousandth part of a second to pass from the first wire in the gun to the next. Similarly, if the distance between the marks on the first and last discs were five inches, this would indicate that the time the shot took to traverse the whole length of the gun was five-thousandths, or one two-hundredth of a second. In reality, the time is even shorter than this. In the 10-inch gun, a 300-lb. shot, with a charge of 43 lbs. of powder, passes down the bore in something less than the one two-hundred-and-twentieth part of a second. So delicate is this apparatus that, by dividing each inch of circumference of the discs into thousandths with the help of the vernier, the one-millionth part of a second would become an appreciable quantity.

It is found, by careful experiment with these appliances and the crusher gauge (by which pressure is estimated by the compression of a copper cylinder placed in the bore of the gun), that the denser the powder is the slower it burns, giving a lower initial velocity to the shot, and exerting a smaller strain on the gun. As an instance of the great differences caused by the smallest variations in density, we give the following results of an experiment with the 10-inch gun, with a charge of 70 lbs.:—

Density.	Initial Velocity, Feet per Second.	Maximum Pressure, Tons on Square Inch.
1·732	1474	29
1·782	1432	21

Here an increase of ·05 in density reduced the velocity by 42 feet, and the pressure by 8 tons. This shows the importance of obtaining a uniform density in the manufacture. For this purpose it is not sufficient to use a uniform pressure in the press-house, as even then the density of different pressings will vary on account of the changing state of the atmosphere, the different degrees of moisture in the powder meal, its varying bulk and elasticity, and other minor causes. The only practicable method of securing an approximately uniform density is to test the product of various pressings and then mix them, so as to reduce the whole to the average density required, and this is the constant practice at Waltham.

We have alluded incidentally to the decrease of pressure in the gun as the density of the powder increases. With the immense guns constructed in recent years it is important to reduce the strain on the metal as far as possible, as this is the only way in which the gun can be safely fired. But it must be remembered, that by seeking to accomplish this by indefinitely increasing the density of the powder, we would at the same time decrease the velocity of the shot, or, in other words, its useful effect. Artillerists have, therefore, had recourse to the expedient of using a powder, each grain of which is a lump of press-cake. The effect of this is to make it burn slower than grain powder; for these lumps, when ignited at the surface, burn, as it were, in concentric layers until the whole is consumed, and by this means the explosion, though to all appearance instantaneous, is in reality much more gradual than that which follows the ignition of smaller grains. In other words, the explosion of the charge in a heavy gun is made to be less of the character of a violent blow on the sides of the bore and the base of the shot, and more like a gradual shove given to the shot with a corresponding pressure on the gun.

The first form proposed for cannon powder for heavy guns was that invented in America by Dr. Doremus, in which the whole charge was made into a solid disc, the size of the bore of the gun. This, however, was found to give very unsatisfactory results. Then the Russian Government adopted a powder compressed into large hexagonal prisms, and in Belgium another powder was made in the form of cylindrical pellets. This was adopted by our Government, and an immense sum was spent on erecting machinery at Waltham for its manufacture, but the pellet powder has since been superseded by a simpler form, much easier to make, and giving better results; and the pellet machinery has been altered, and, we believe, is now used in the manufacture of gun-cotton.

The pebble powder now in use consists of cubes of compressed gunpowder, with sides about four-fifths of an inch square.

These pebbles are made by passing press-cake of that thickness between two pairs of rollers, armed with sharp-cutting edges. The first pair of rollers by means of these edges cuts the cake into several small bars, about four-fifths of an inch square at the ends, and these bars, on passing between the second pair of rollers, are divided into cubes or pebbles. After having been rolled in a hollow cylinder, or reel, to round off the sharp edges and get rid of the dust, the pebbles are carried to the drying-house to be freed from the moisture they contain.

The drying-house is a large room with double doors, and fitted with racks from floor to ceiling. On these racks copper and wooden trays are placed, containing the powder spread out in thin layers. Steam pipes are introduced from a boiler in an adjoining building, and thus the air of the room is kept at a temperature of about 135°. The firemen in charge of the drying are forbidden to enter the room for fear of carrying in a spark in their clothes, but they ascertain the temperature by a register thermometer placed inside a small window, and this thermometer also acts as a tell-tale, by showing if the temperature has at any time been allowed to become too high or too low. So perfect are all the arrangements at Waltham, that no explosion has ever occurred in the drying-house.

The dried pebbles are finished by being placed in a revolving barrel (called a glazing barrel), with a certain amount of powdered blacklead. On being taken out, every pebble is found to have a perfectly smooth surface coated with blacklead, the effect of which is still further to diminish the rate of burning. The pebbles are then thrown into sieves to separate small fragments; all irregular pieces are picked out by hand, and the remainder is packed in ordinary powder barrels, which would hold 100 lbs. of rifle powder, but contain 125 lbs. of the pebble powder, on account of its greater density.

The following results of experiments with the 8-inch gun will give the reader an idea of the effects of the different kinds of powder. We need only explain that R.L.G. means the old "Rifle Large Grain" powder still in use for field artillery, and draw attention to the fact that the pebble powder gives at once the highest velocity and the lowest strain:—

Powder.	Charge. Lbs.	Initial Velocity, Feet per Second,	Maximum Pressure, Tons on Square Inch.
R.L.G.	30	1324	29·8
Russian Prismatic	32	1366	20·5
Service Pellet ...	30	1338	17·4
Pebble	35	1374	15·4

Visitors to the laboratory at Waltham can see there a number of experimental varieties of pebble powder, the largest of which consists of cubes as hard as stone, each side of which is two

inches square. A shower of this alone fired from a gun would be quite as effective as grape, and it is possible that 300 lbs. of this tremendous powder will form the charge of the new 80-ton gun.

For rifle powder the meal is pressed into thin cakes; these are broken up into irregular pieces by hand, and carried to the granulating machine. This machine consists of four pairs of toothed cylinders, between which the broken cake is passed. As it falls from them in grains, it is received upon a series of screens of network. There are three of these, the texture of each being closer than that above it, so that large-grain powder is retained on the first, while fine-grain and dust fall through it. The fine-grain remains on the second, and the dust passes on to the third. All the screens are placed in an inclined position, so that the powder runs down them into tubs arranged at the lower end, one of which receives the large, another the fine-grain, and a third the dust.

The powder is then rolled for some hours in the glazing-barrels, to break off all minute irregularities, and give it a smooth surface. Then it is dried, and finally freed from dust in the slope-reel. This done, it is finished by being passed once more through the glazing-barrels, and it is then packed in barrels of 100 lbs. each.

Such is the process of the gunpowder manufacture in the Royal Factory at Waltham. We have only briefly indicated the principles of each process, for to go into detail would occupy far greater space than is at our command; but even this sketch will show how at each step science has been called in to aid art in bringing the manufacture to its present high state of perfection. No expense is spared in procuring the best materials, the most efficient machines, and the most accurate tests; yet the cost of manufacture is only about sevenpence per pound. What a contrast to the early days of gunpowder making, when in France, in 1375, a pound of gunpowder cost a sum equal to ten pounds of our money!

In every department the greatest care is taken to prevent the danger of explosions. The houses are built from two to four hundred yards apart. Wood, copper, and gun-metal are the only materials used in the structure of the machines, except where, and that rarely, a bolt of iron is introduced for the sake of strength, and then the metal is encased in leather. The floors are covered with hides secured with copper nails, and these as well as the wooden platforms round the houses are kept constantly wet. All loose powder is swept away from the floors, damped, and carried to a magazine, where it is collected and the saltpetre subsequently extracted. No one is allowed to enter a room without putting on a pair of leather "magazine

shoes" made without nails, as the iron nails in ordinary boots might lead to an explosion if one trod on the loose powder; and, moreover, one would be certain to bring in grains of grit, which are so dangerous if they become mixed with the powder. The men wear a kind of fire-proof clothing, and in the incorporating-houses leather caps and gloves. Fire-engines are stationed in various parts of the factory, and every man has his post assigned to him in the event of an alarm of fire. To such an extent are these precautions carried that the roofs and eaves of the buildings are searched for birds' nests, and they are pulled down whenever they are found, lest the birds in building or bringing food to their young might drop grains of grit or sand on the platforms round the houses. Every building is protected by lightning-conductors, and as soon as a thunderstorm approaches the men have orders to stop the machinery, leave the houses, close the doors, and cease all work until it has passed over. But the best security for the safety of the factory is that the workmen are a body of steady, industrious, intelligent men, and bear so high a character that a dismissal is a rare event, though it is the penalty of any breach of a necessarily strict code of rules.

The powder manufactured at Waltham is carried down the River Lea to be stored in the great magazines at Purfleet. A useful lesson can be learned from the method of transport. The gunpowder is conveyed in barges specially constructed for the purpose. They are about half the length of an ordinary canal-boat, and are covered with a semi-circular roof, with a door at the side, which is kept closed, except when the boat is being actually loaded or unloaded. Every powder-barge is considered a magazine, and the same rules apply to it as to the Government magazines. No fire or light is allowed on board: nothing but powder is to be placed in the hold; and no one is allowed to enter it without wearing the ordinary magazine shoes. In this way it may be said that every chance of an explosion is carefully guarded against. It would be well if the same method of transport were used on canals where (as on the Regent's Canal) gunpowder is being continually carried to and fro. The extra expense of having special barges would not amount to one-hundredth part of the loss caused by an explosion.

We have also to consider the transport of gunpowder by road. It is said that it is a common thing for cartloads of gunpowder to pass through the crowded streets of London, sometimes several carts closely following each other, and crowding together if there is a block in the traffic. This is unquestionably a very dangerous practice. It would be well if carts laden with any considerable quantity of gunpowder could be prevented from entering the streets of a town; but in many cases this

would be impossible. The transport, however, might easily be rendered much safer, by forbidding gunpowder-carts to pass along the streets except during a few hours in the morning, allowing only covered vans to be used, and fixing certain intervals within which no van should approach another. Finally, powder should never be packed in the light kegs used by some manufacturers, which are continually liable to leak, for loose powder is always exposed to ignition by any one of a hundred accidents. There are cases recorded of explosions having taken place through powder leaking from a tumbril, and forming a train upon the ground, which was fired by a spark struck from the shoes of one of the horses drawing it. Good strong barrels should always be used, and they could of course be returned when empty.

After the Regent's Park explosion there were some fears expressed as to a possible explosion at Purfleet, where about 50,000 barrels of gunpowder are stored in five large magazines. If five tons on board the canal-barge could do so much damage, what, it was asked, would be the effect of an explosion of the 2,000 tons at Purfleet? Attempts were made to calculate the radius of destruction by Mallet's formula for the effect of bursting shells—the fact being disregarded that the bursting of a shell and the blowing up of a magazine are essentially different affairs. We were told how all East London would suffer from the shock, how several villages in Kent and Essex would be destroyed, and how trains would be thrown off the railway-lines, gasometers wrecked, and a wide district plunged into darkness. We must not forget that an explosion in the open country would have relatively much less force than an explosion in the midst of closely-built streets like those about Regent's Park. An explosion at Purfleet would be very terrible, but probably not half so destructive as one might expect at first sight.* Then the Government must keep this large store of powder somewhere; 50,000 barrels could not be manufactured on an emergency, and Purfleet offers advantages in the way of safe and easy transport from Waltham, and shipment to India and the Colonies, which mark it as a good site for our chief magazines. The gunpowder might indeed be distributed in numerous magazines, at various points along the lower part of the Thames, but this would really be to increase the chances of an explosion; for the more numerous is the staff of superintendents

* The explosion of a large magazine is really the successive explosion of various portions of its contents, not the detonation of the whole mass. This is why it is fallacious to attempt to estimate the effect of the explosion of 2,000 tons by comparing it with the explosion of a large shell, or of a few barrels on board a barge.

and storekeepers, the greater is the danger of carelessness on the part of some amongst them.

Many a one has said, with the foppish young lord, who so much excited the anger of Hotspur at Holmedon,

> That it was great pity, so it was,
> That villainous saltpetre should be digged
> Out of the bowels of the harmless earth,
> Which many a good tall fellow had destroyed.

But, strange as it may seem at first sight, gunpowder and such compounds are as much used in peace as in war. What with practising, salutes, experiments, and reviews, our Army, Navy, and Volunteers burn every year as much gunpowder as would be required for half-a-dozen battles and a siege or two. But it is in mining, quarrying, and engineering works; in a word, for industrial purposes generally, that gunpowder is chiefly used; and as strife and peaceful industry cannot exist together, a war, on the whole, tends to lessen rather than increase the consumption of explosive substances. During the great conflict in America the sale and import of gunpowder fell off enormously. It is said that the same thing was noticed in France during the Crimean War; and probably the present war in Spain, by stopping the iron mines of the North, has diminished the import of blasting powder to a greater extent than it has accelerated that of powder specially manufactured for military purposes.

The following figures will give an idea of the amount of gunpowder employed in mining operations. It is estimated that in coal-mines about 80 lbs. of powder are used for every thousand tons of coal raised. In mines of lead and other minerals, which are found in hard crystalline rocks, about 7,000 lbs. of blasting-powder are required for every thousand tons of ore. To quarry a similar quantity of sandstone 170 lbs. would be used; while for the harder granite the amount would be 650 lbs.

The quantity of gunpowder exported from England has not increased very rapidly of late years. In 1860 it was 11,078,436 lbs., of a declared value of 353,101*l*. In 1865 it had risen to 16,833,723 lbs., valued at 457,078*l*.; and in 1870 it was 17,357,668 lbs., valued at 427,229*l*. The increase in weight, with a decrease in value from 1865 to 1870, is due in a great measure to the fact that we export an immense quantity of gunpowder of an inferior quality to non-British ports in Western Africa; and it is in this cheap sort of gunpowder that the chief increase has taken place, while there has been a falling off in the more valuable kinds. Thus in 1870 no less than 4,637,066 lbs., or more than 25 per cent. of the whole export,

went to Western Africa, chiefly to satisfy the warlike propensities of woolly-headed kings; but it will be seen at once what the quality of the powder was, when we add that its declared value was only 83,657*l.*, while the comparatively small quantity of 1,173,762 lbs., exported to France, was worth 75,522*l.*, or about four times as much in proportion to its weight. Heavy as our loss was at Amoaful, it would have been much more severe if the Ashantees had been provided with something better that this worthless powder. As it was, several of the men in the front line were struck five or six times without being wounded, the bullets having such little force that they fell harmlessly to the ground.

THE ORIGIN OF OUR ENGLISH SCENERY.

BY HORACE B. WOODWARD, F.G.S.,

GEOLOGICAL SURVEY OF ENGLAND AND WALES.

THOSE, albeit not geologists, who contemplate our English scenery, and by many journeys have studied its varied forms, may derive much additional pleasure from knowing how these forms originated, and why in one place there is a hill and in another a valley. They may not care to examine into every detail upon which a knowledge of the causes of this variation is founded; that would be a minute and perhaps tedious subject: but it will prove interesting to all to know in a general way how the leading features of our country have been formed.

The subject is intimately connected with the principles of geology, and in this respect, since the days of Hutton and Playfair, it has been largely treated of and discussed by our leading geologists.

Our hills and dales are mainly due to what is termed Denudation, or the laying bare of different rocks by the gradual wearing away of those previously above them. The general structure and arrangement of the different rocks in England is such that some were disturbed, upheaved, and denuded before others were deposited upon them, and therefore the forms of scenery are partly due to disturbance or elevation, though mainly to denudation.

In order to comprehend the forms of denudation that have taken place, we have only to regard what is taking place now; the work is carried on by rain, rivers, and the sea—water is the great agent—while in former times ice, in the shape of glaciers, had considerable influence in our country in wearing away the hills and in shaping the valleys.

The effects of the sea are patent to all, in the gradual ruin of our cliffs and waste of our coast line. The effects of rivers are to be estimated best by the amount of solid matter which they bring down with them; while the action of rain is partly combined with that of rivers, and is partly of a chemical nature; the carbonic and other acids which it imbibes in its course through the atmosphere and the soil assisting largely to form

caverns, and displaying their action in a lesser degree in the fantastic shapes and hollows so often seen on the exposed surfaces of limestone and other rocks. With rain, other atmospheric agencies must be noticed, such as frost, which acts forcibly in the disintegration of rocks, particularly those exposed in cliffs and ravines. Rain and frost thus largely aid the marine denudation on the sea-cliffs.

The effects of ice are clearly traced by the presence of phenomena similar to those produced in countries where glaciers now exist.

It must be remembered that the area now embraced by England has many a time been submerged beneath the ocean, and, indeed, the different rocks or strata of which it is composed are almost entirely the consolidated ooze, mud, sand, and shingle of old sea-bottoms. These are our stratified rocks, and they have most of them (directly or indirectly) been formed by the destruction of some pre-existing rocks, which formed the hills and the cliffs along the old sea-margin. Of what rocks the earliest hills and valleys were formed it is not easy to say, but they must all have belonged to the igneous class, and have been of a more or less crystalline nature. The history of the earth, as told by our stratified rocks, indicates an incessant change. No new materials are added (if we except the slight additions made by meteoric stones and dust), but all are ever undergoing some change either in form or in combination.

From the greater portion of our rocks being deposits formed in the ocean, it might at first naturally be supposed that the sea was the great agent of destruction. A few moments' reflection will, however, show how erroneous such a conclusion would be, for the greater part of the material worn from the land is carried out to sea by rivers, and there mingled with the marine shells and the sediment due to the waste of the sea-cliffs; so that it would evidently be giving too much credit to the destructive power of the sea, great as it is, to consider most of the matter deposited at its bottom as owing to its wear and tear.

The earlier deposits having been upheaved and formed dry land, while other and newer deposits were being formed, and partly by their destruction, it follows that, during repeated elevation and submergence, the older rocks will have suffered more by denudation of all kinds than the newer. Moreover, they having been subjected to great pressure from superincumbent strata subsequently removed, and having been more altered or metamorphosed by contact with igneous rocks than the newer strata, their texture is or has been continually hardening, and therefore the older rocks as a rule are of a more stony or slaty nature than the newer, which in most cases have suffered little from volcanic or igneous action.

These facts will help us when we come to consider the varieties of scenery. The older rocks have been more subject to denuding agents than the newer, and yet as we now see them they are more capable of withstanding the effects of denudation. Beds of a clayey nature or soft sandstones are more easily worn away than slate, limestone, or grit, and consequently the latter form ridges, escarpments, and the summit of table-lands, while the former are exposed in hollows and valleys. The texture of the rocks has thus an important influence on scenery apart from age, although, as we have seen, the older the rocks, so generally are they the harder.

In studying the causes and effects of the denudation of England and Wales, we may divide the subject into two parts:—(1) That which has affected its grand features; and (2) that to which its minor features are due. In the former case we may see that the age of the different formations enters chiefly into the origin of the scenery; in the latter case the lithological characters of the different rocks come most prominently into play.

The grand features are due, firstly, to great lines of elevation, and secondly to the effects of denudation.

In noticing the effects of elevation, and the age of the rocks, we may observe that the oldest palæozoic rocks form, as a rule, the most elevated scenery, as in North Wales and the Lake District. The old red sandstone forms undulating scenery of considerable elevation, as in Herefordshire, the Mendip Hills, &c.; while the Devonian rocks of Devon and Cornwall (which may be partly of carboniferous age) form equally bold scenery, and by the nature of their strata often rival in grandeur that of the older slaty rocks. The carboniferous rocks form scenery that is conspicuously their own. The mountain limestone is celebrated for its combes or dales, as the counties of Derby and Somerset well instance; whilst the millstone grit, yoredale rocks, and coal measures form hilly and somewhat barren country, often moorland, as in our coal districts, in the Peak country, Glamorganshire, and elsewhere.

When we come to the red rocks, or those of Permian and Triassic age, which form a belt across the country from Torquay and Sidmouth to the mouth of the Tees, we find a low-lying series of vales, which are different in their agricultural character and scenery from the older rocks, which bound them roughly on the one side, and the newer on the other. "The part to the north-west of this line is chiefly palæozoic ground, often wild, barren, and mountainous, but in many places full of mineral wealth; the part to the south-east of it is secondary and tertiary ground, and generally soft and gentle in outline, with little or no wealth beneath the soil. The mining and

manufacturing populations are to be found in the first district; the working people of the latter are chiefly agriculturists."*

The lower beds of the lias and the rhætic beds form a gentle escarpment above the triassic series, bordered generally by the escarpment of the oolites,† which stretches from Dorsetshire, by the Cotteswold Hills, to the Yorkshire coast.

The next principal feature is the escarpment of the chalk forming the North and South Downs, and Salisbury Plain; stretching from the Chiltern Hills into Norfolk, and again appearing in the wolds of Lincolnshire.

The tertiary clays and sands are all of a more or less yielding nature. They form tracts of low lying and gently undulating country, in Hampshire and in the Eastern counties.

The most recent deposits of alluvium (sediment deposited by existing rivers and estuaries) form tracts of almost level land, such as that which borders the Thames, conspicuously between London and Tilbury, the Fenland, and the Somersetshire levels.

It will be easily understood why the alluvium should form such scenery as it does—belts of low-lying meadow-land bordering the rivers and streams—but why the rivers should have formed so much sediment along their courses is not at once easy to understand. It must be remembered, however, that in all times, from the most remote to the present day, changes of level continually take place, and such changes greatly affect denudation and deposition. A slight submergence would cause a river to flood its banks and deposit sediment, whereas elevation would tend to make it deepen its channel, and so remove more material. A river, as is well known, is incessantly changing its course, in however small a degree, and when we see broad flats of alluvium bordering a small stream, it does not follow that the stream once entirely filled that broad channel, but that in the course of time it has occupied different positions in that valley.

Alluvium, which is often restricted to the river mud, may very properly include the beds of gravel deposited by the river. These beds of gravel, which are often very extensive, are seldom entirely formed by the river itself; they are often made up to a large extent of beds of gravel previously formed. Thus, much of the Thames valley gravel is only derived from pre-existing glacial gravels, which are themselves made up in great part of old shingles belonging to the tertiary and triassic periods.

* See "Manual of Geology," by Jukes and Geikie, p. 617.

† This is used as a general term, to embrace what is really a series of minor escarpments, although, looked at in a large way, the oolites form one striking feature.

The history of the origin of our rivers and their valleys is a large subject, and one which opens up many difficult questions in physical geology. The subject was first clearly brought into notice by the late Mr. Jukes; and Professor Ramsay, who has paid great attention to it, has treated of the origin of several of our most important rivers. As it is largely connected with the origin of much of our English scenery, we must give some attention to the results of their observations, but before doing so it may be well to point out in a general way the origin of the great features.

Many years ago Professor Ramsay noticed that in drawing a section through Wales, through the more hilly or mountainous regions, a line might be drawn from one end to the other, which would touch, or nearly touch, all the more important elevations. The whole of the rocks of palæozoic age which form these regions are much disturbed or contorted, being bent into folds, and at the same time irrespective of the shape of the hills. He demonstrated that, while filling up the valleys in imagination, there yet remained a vast amount of material that had been removed above the line which touched the tops of the hills. This line indicated to him a plain of marine denudation. Before the tract was elevated to its present position the sea worked away gradually, as it does now on many parts of our coasts, such as at Watchet or near the mouth of the Thames at Southend, forming a plain of rock (whether stone or clay) barely covered at low tide. The plain formed in Wales was, of course, a very extensive one, and then after the area was elevated atmospheric denudation came into play. Rents, joints, and fissures in the rocks no doubt gave a first direction to many of the valleys, which have been enlarged by rain and streams and rivers, and even by glaciers. So that really the main features of Wales, as we now see them, are due chiefly to fresh-water denudation, although there is every reason to suppose that the sea exercised some modifying influence on the land during the long course of ages and the many changes it has seen since the later palæozoic times.

We may now turn to the escarpments of the oolites and chalk, which are the next grand features we have to consider. Professor Ramsay believes that the lias and oolites entirely surrounded the old land of Wales, passing westward through what is now the Bristol Channel on the south, and the broad tract of new red formations that lie between Wales and the Lancashire hills, now partly occupied by the estuaries of the Dee and Mersey. He considers, too, that the chalk in its day also spread far to the west, covering unconformably the half-denuded oolites, till in its early beginning it also abutted upon the ancient land formed of the palæozoic strata of Wales, and by-

and-by, as that land sunk in the sea, buried it perhaps in places altogether.*

We now find the chalk and the oolites forming long lines of hilly ground or escarpments, as they are termed, with here and there an outlying hill. The rivers, too, often cut directly through them in the most remarkable manner. The rocks forming these escarpments dip, on the whole, gently to the south-east, a feature produced, no doubt, during elevation of the strata above the sea-level.†

Before the chalk and other cretaceous strata were deposited in the West of England, the oolites and lias had been disturbed and denuded, so that the former beds overlap the successive members of the latter. The older strata seem to have been planed off, and probably by the sea, before the chalk and green sand were deposited.

The chalk escarpment was, therefore, no doubt (in certain areas) the first *escarpment* formed. After it had been denuded beyond the outcrop of the oolites, then the escarpment of those rocks began to be formed.

Professor Ramsay has taught us that the reason why so many rivers cut through escarpments is that they originated before the escarpments were formed, and cut their way down through the strata, which afterwards, by atmospheric denudation, receded. The fact that escarpments have thus receded is plain, although rather difficult to account for. Their formation is often attributed to marine action, but there are so few facts to corroborate this notion, that the opinion now generally held is that they are, for the most part, due to the silent and slow process of atmospheric denudation, of rain and tiny streams and rivers. The chalk escarpment, as Professor Ramsay observes, being more easily wasted than that of the oolites, its recession eastward has been more rapid.

The facts that escarpments are formed almost invariably of porous rocks, such as limestone or sandstone, while at their base is exposed a clayey or marly series of strata impervious to water, which, perhaps, again rest on hard rocks, forming another escarpment, the beds in it dipping away from the plain beneath, are all-important in forming true notions of their origin.‡

The beds may have been reduced to a tolerably even level by

* "Physical Geology and Geography of Great Britain." Third Edition, pp. 95, 96. Whether the chalk ever covered the whole of Gloucestershire and Somersetshire is by no means certain.

† On this subject see Topley, on "The Correspondence between some Areas of Apparent Upheaval and the Thickening of Subjacent Beds." Quart. Journ. Geol. Soc., vol. xxx., p. 186.

‡ On this subject see Whitaker, "Geol. Mag.," vol. iv., pp. 447, 483.

marine denudation, after being subjected to the disturbances and undulations produced during their elevation; and these very disturbances may have partly affected the character of the plain of marine denudation, which does not necessarily mean a dead-level, and gentle curves or slight ridges of the harder rocks may have been left as a guide to the subsequent sub-äerial denudation.

The rivers that cut through the escarpments are fed by streams that run parallel to the escarpments, and though the actual denudation may appear trivial, yet when rightly estimated by geological time, it will be understood, and a true conception of the magnitude of sub-aërial denudation arrived at.

The denudation of the Wealden district has been a fertile source of discussion, and has an important bearing on the origin of escarpments. It will be unnecessary here to refer to the many papers that have been written upon the subject, and we may be content with giving Professor Ramsay's views.* By drawing a section across the district from the North to the South Downs, and connecting the chalk and other strata on either side, a dome-shaped or anticlinal structure will be formed. This dome was probably removed by the sea, which formed a sort of plain of marine denudation, leaving at the same time a sort of low central watershed, from which in old times the rivers probably flowed, and thus formed their channels through the chalk, which seems inexplicable on other suppositions. In due time the rain and river action diversified the scenery, the chalk escarpments receding, the soft gault forming a hollow, the lower greensand standing out in bold hills, overlooking the plain of weald clay, and the harder rocks of the Hastings sand series again rising in hilly ground.

From what has been said, it will be seen how many of our rivers date from very early times, although their courses have been at times enlarged or contracted by elevation and depression.

The nature of the river valleys of course depends upon the nature of the rocks traversed by the river, bold cliffs being formed in hard rocks, and hardly any or none in soft strata. The alternation of hard and soft strata along a river course may lead to the formation of a lake, the softer strata being worn away, and the harder forming barriers at either end. Lakes, indeed, may be due to various causes or a combination of causes. Glaciers may plough out hollows, or deposit moraines, which form barriers. Faulting and disturbance of strata in some cases appear to have had considerable influence in the

* The same views were worked out in great detail by Messrs. Foster and Topley. See "Quart. Journ. Geol. Soc.," vol. xxi., p. 443.

formation of lakes, and it is well to be cautious, in studying the origin of lake-basins, to bear in mind the many and complicated causes to which they may be due.

These questions belong to the minor features in our scenery. They have been produced by many local causes, and it is impossible here to treat of them in any but a general way.

The influence of glaciers, which are well known to have existed on the high grounds of Wales and in the lake district, has been spoken of, and some of the valleys have been considerably modified, if not to a great extent formed by them.

In limestone districts, as in Derbyshire and Somersetshire, the power of rain-water holding carbonic acid is very great in dissolving the rock and forming caverns, and sometimes, when the conditions are favourable, re-depositing the carbonate of lime in the form of stalactites or stalagmites; or, again, forming a petrifying spring and encrusting leaves, shells, and other objects with a deposit of tufa. It has been supposed that some of the dales and ravines may originally have been caverns. Be this as it may, the action is the same—these limestone combes and dales have been formed by running water, assisted, no doubt, by the mechanical action of frost, and the chemical action of carbonated water.

We may here also call attention to what is really a very minor point in connection with scenery, but which yet has many points of interest in connection with physical geography.

The origin of certain small holes and excavations in limestone rocks has given rise to much discussion. The atmosphere, pholades, and land snails have severally been called into account for them, and from the observations that have been made, there seems to remain little doubt that all three agents share in boring and burrowing into rocks. By far the larger number of holes and irregular cavities on limestone rocks are undoubtedly due to atmospheric wear and tear, but there are certain small holes more or less regular in shape, about which discussion has taken place. Some are, doubtless, bored by pholas, which can pierce almost any rock, but these burrows are of a pear-shaped or pyriform character, and need hardly be mistaken, although there is no reason to doubt that the atmosphere could mimic these forms, so varied are the shapes it has fashioned. There are other holes, unlike pholas-burrows, and occurring in situations where it would seem that meteoric agencies had no play, which have been attributed by the Rev. T. G. Bonney and Mr. J. Rofe to the action of our common land-snails.

Long ago Dr. Buckland, and subsequently M. Bouchard-Chantereaux, advocated the boring powers of snails, but their views appear to have met with little credence. Mr. Rofe argues very ably for snail-action. The odontophore of the gasteropods,

a cartilaginous strap, bearing a long series of teeth, is capable of a rasping or scraping motion, and this tool he thinks quite capable of producing small cavities in limestone rocks. At the same time, it must be observed that we want more positive proofs of the boring action of snails.

There are some other minor features which deserve a passing notice. The occurrence of large masses of loose rock may be due to the jointage of beds and their being weathered out *in situ*. Other rocks may jut out naturally and be weathered into fantastic shapes, and not only pluvial action may influence them, but in some cases wind carrying sand has exerted great power in furrowing or in polishing rocks.

Most of the palæozoic rocks, and the igneous rocks and granites, jut out here and there on the hill-sides, and form often a rough barren country, when they yield little or no soil. Large blocks of stone may also have been brought from a distance by a glacier or iceberg and so deposited.

It may be thought that the effects of the sea have been rather neglected in this sketch, but it is by no means wished to detract from its power. The shape of the British Isles is in a great measure, although not entirely, due to its action; the irregularities being for the most part produced by the alternation of hard and soft rocks, the former constituting the headlands, the latter the bays. The effects of submergence have in some cases allowed the sea to encroach and modify valleys previously formed by river-action. This action, as we have noted, tends to check the denudation by rivers. While, on the contrary, a fact pointed out by Professor Geikie, "as the land rises the cliffs are removed from the reach of the breakers, and a more sloping beach is produced, on which the sea cannot act with the same potency as when it beats against a cliff-line;" and this action promotes subaërial denudation.

The set of the tides and currents will tend to influence the configuration of the coast-line and promote the travelling of beaches. In some cases the flow of rivers is checked or diverted for a distance by this action. This is notable on the south coast of England, between Exmouth and Portland. The origin of the Chesil Bank forms an interesting study, and, indeed, requires special explanation. Its isolation from the mainland, according to the researches of Messrs. Bristow and Whitaker, is due to the subsequent subaerial denudation of the land which intervened, and which area is now occupied by the Fleet.

Hillocks of blown sand are produced where there is a great expanse of sand at low tide, subject to the influence of the prevalent winds blowing inland.

In summing up the causes of denudation and their effects upon scenery, it may be remarked that there has been a great

tendency to extreme views, and particularly in attributing too much to marine action.

We have seen that the effects of elevation and disturbance are not unimportant; that, indeed, in the first place they gave the plan to the denuding forces; rents and fractures, even faults—all have in some way influenced the minor features, while the dip of the strata and the texture of the different rocks have likewise affected the configuration of our land. In this respect the angle of repose is important, and may well be studied in our railway-cuttings.

Professor Geikie has compared the work done by rain and rivers, and that done by the sea. It has been estimated that the Mississippi carries annually to the sea about 812,500,000,000 lbs. of mud! Allowing the sea to eat away a continent at the rate of ten feet in a century, and that on a moderate computation the land loses about a foot from its general surface in 6,000 years, then, before the sea could pare off more than a mere marginal strip of land, between seventy and eighty miles in breadth, the whole of Europe would be washed into the ocean by atmospheric denudation.*

This estimate seems to do bare justice to the sea, but it is evident, as Professor Geikie remarks, that the extent of land exposed to subaërial or meteoric agencies far exceeds that exposed to the influence of the sea.

All agencies, however, act in concert; the landslip caused by rain and frost and the dip of the strata is removed by the sea, and the deposits formed at its bottom are upraised and returned to it again by rain and rivers. Thus we find that the whole plan of Nature is one of constant creation and decay. Man has done much to check the wasting action of the sea on our coasts by the erection of groynes and other defences, while by the cutting down of forests he has lessened the rainfall, and consequently diminished the effects of subaerial denudation. Nevertheless, his power has been but feeble in the history of our planet, while his time on earth has really been but a moment compared with the long ages of geological time. And yet the history of each rock, if we consider Man as the ulterior object of creation, has not been one of chance or without design, when we look to the important benefit that they have conferred upon him by the various economic purposes they serve. Nor is the influence of our scenery to be looked upon as accidental, for what more powerful influence for good is there upon the mind of man than the contemplation of a beautiful landscape, and in learning from it something of the wondrous works of Nature as exhibited in the history of our rocks?

* "Trans. Geol. Soc. Glasgow," vol. iii. p. 153.

REVIEWS.

THE GERMAN ARCTIC EXPEDITION OF 1870.*

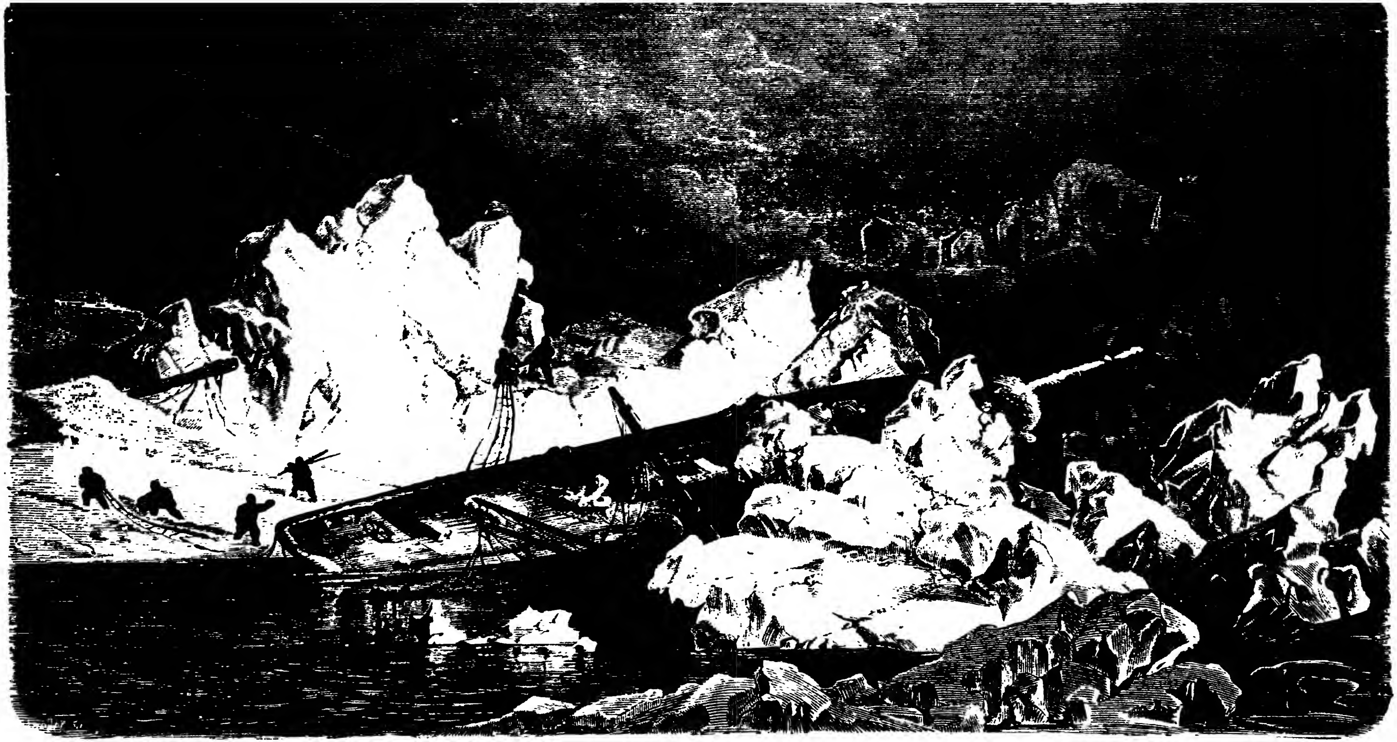
EVERYONE who is at all interested in the proposed Arctic exploration for which our Government are at the present moment preparing, should read the graphic account of the recent expedition of the German explorers, which has been so well related by Captain Koldewey and his several junior officers, and so well translated into English and edited by the Rev. L. Mercier, M.A., and H. W. Bates, F.L.S., of the Geographical Society. It must be confessed at first that the results of the expedition are somewhat small, that is, as regards the amount of discovery either in the domains of geography, biology, or physics; at least, if we are to regard the present work as a faithful and full narrative. Still, as an historic account of the grave disasters suffered, and the patient determination of the men to bear with all risk and danger in making their way to the extreme latitude of 77°, it cannot be excelled. When to this we add that in point of excellence and number of engravings it is almost unsurpassed, that the book is simply one mass of illustrations, some of them exquisitely coloured, we shall have said enough to urge our readers immediately to possess it.

The general facts of the expedition may be briefly summed up as follows: On the 15th of June, 1869, the two vessels, the *Germania*, a steamer of about 600 tons, and a small schooner, the *Hansa*, left Bremen haven, in the presence of the King of Prussia, Prince Bismarck (then Count von B.), General von Moltke, and others, and were towed out of harbour by a couple of tugs. In the evening they fairly started on their journey northwards, their intention being to explore the east coast of Greenland as far as latitude 77°. It was originally thought that both vessels could keep together throughout the voyage. However, fate decided otherwise. The two vessels some time in July lost each other for a few days as they approached the ice. The loss was followed by a reuniting, when the crews of both were excessively rejoiced at the result. They parted company, however, the next day, and never met together again, and this was on the 20th of July, after mid-

* "The German Arctic Expedition of 1869–70; and Narrative of the Wreck of the *Hansa* in the Ice." By Captain Koldewey, Commander of the Expedition, assisted by Members of the Scientific Staff. With numerous Woodcuts, Maps, Portraits, and four Chromo-lithographs. Translated by the Rev. L. Mercier, M.A., and Edited by H. W. Bates, F.L.S., Assist. Sec. Royal Geographical Society. London: Sampson Low & Co., 1874.

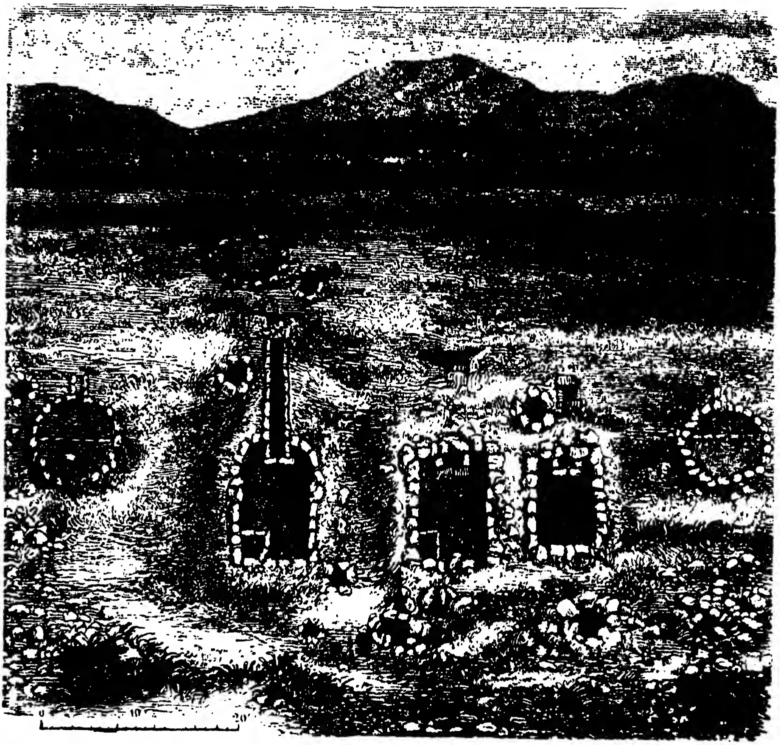
night, and when they were already in latitude 75°. This was the highest point to which the *Hansa* reached. Following this vessel alone now, we are told various tales, all of which record the extreme cold, the violent storms, and the various efforts made by the men to manage this extremely small and, we should think, unsatisfactory vessel. We do not think that the captain, Herr Hegemann, left anything undone which could have saved her. However, it was in vain. The vessel lay in a mass of ice; great blocks, many of them higher than her deck, surrounded her; and of course, under the combined pressure of the ice and her weak condition (she was not iron-bound, as was the *Germania*), she eventually became so leaky that the captain saw she must become a total wreck. Here was a condition! The crew had, of course, to leave the ship, which was fast sinking, and to set up a home of some kind in the huge wilderness of ice in which they were, and which was simply and solely the frozen ocean. What an awful condition to be reduced to! Yet they all bore it bravely. They set to work with a will, getting as many things as possible overboard, but still compulsorily allowing a considerable quantity of coal and other materials to remain within the sinking ship. At last they had got all they could collect from her on to the ice, and they saw her go down beneath it, with the great bulk of all their scientific apparatus and natural history collection. Their lives were now utterly unprotected, and from this period—night between October 21 and 22—they remained residing upon and carried southward with the ice till May 7, 1870. Now this period is full of adventures of all kinds, and it is faithfully and well described in the pages of this volume. They, of course, saved their boats, and in these, having abandoned the floe, they travelled south to the island of Illindlek, which they reached on June 4, 1870. On June 13 they arrived at Fredericksthal, where they stayed some time, making a series of excursions, and from which they were eventually taken by a small vessel to Copenhagen, whence they reached Hamburg on September 3, 1870—a time when, indeed, they must have been struck with wonder and astonishment, for on that day the news of the mighty battle of Sedan flew over nearly every civilised country in the world, and must unquestionably have astounded these patient explorers who had travelled from the polar world. Thus ended one part of the expedition.

The explorations of the *Germania* were, as we might have expected, from her better build, larger size, and steam appliances, infinitely more successful. In the first instance we may state that the *Germania* reached a latitude as high as 77°, being, in point of fact, considerably north of Cape Bismarck. Very interesting are the descriptions of the scenery, and the admirable plates, some coloured, that occur in this part of the volume. The explorers, of course, did not do very much during the earlier part of the winter, for they were obliged to harbour their ship at Sabine Island, and build a series of walls of ice around her, to protect her hull. Then follows a long account of the various occurrences and pastimes by which the ship's crew managed to pass through the depths of winter; and this account of the period during which the days and nights were completely given up to darkness is interesting in the extreme. About the beginning of March, however, the explorers thought of going further north, and so they set out with a sledge, which, in the absence of dogs, was drawn by themselves for more than three



Sinking of the Hansa.

weeks, amid circumstances the most trying that it is possible to imagine. In one instance the cold appears to have been intense indeed, for "all food was frozen—even brandy began to freeze one night—meat in the tins or ham had to be chopped with the axe; butter could without any fear be carried in the waistcoat-pocket, to be enjoyed on the march." Still, however, they reached the 77th degree of latitude, which on the east coast of Greenland is a perfectly virgin soil. Here they terminated their journey northwards; and having erected a cairn, they placed in it a box containing a document worded as follows: "This spot, which lies in 77° 1′ North latitude, and



Ruined Esquimaux Huts and Tent-rings.

18° 50′ West longitude from Greenwich, was reached by the German Arctic Expedition in sledges (the last three German miles on foot), starting from the winter harbour by Sabine Island, after an absence from the ship of twenty-two days." The return journey to the ship was as eventful as the one already undergone; and after this was completed they made, among other excursions, one which is of some interest, to the remains of an Esquimaux settlement. The following account is given of this: "On the shore facing the south-west we discovered a long row of graves, heaps of stone so evidently built by the hand of man that they must at once strike the eye;

beside them were the upper parts of four well-preserved earth-huts belonging to the natives. These were remarkable even in the distance by a small crater, edged with a circle of stones. . . . . Upon coming nearer square open holes were to be seen, half in the earth, built over with strong stone walls, from which a massive underground passage led into the open air." Then follows a minute account of "those curious huts, which certainly lead us to class them as an exceedingly primitive style of dwelling. The rings were simply the outlines of a tent, and are common enough in West Greenland."

We have said enough to show the reader how exceedingly interesting is this book, but we have not said enough of the illustrations, which are admirably drawn and well painted. Especially can we commend the coloured illustrations, which are to our mind some of the very best work of this description that we have ever seen. Altogether the book is one which the German nation may well be proud of.*

CHINA, INDO-CHINA, AND THE STRAITS OF MALACCA.†

ALTHOUGH the present work can hardly be called a scientific one in the strictest sense of the word, still, inasmuch as geography is to a certain extent unquestionably scientific, it must therefore pass muster in the ranks of scientific literature. Still, Mr. Thomson has been, to a certain extent, possessed of the powers of observation of a keen naturalist, and he has given us in this volume views of China, both with pen and pencil, which are perfectly original, and some of them are of the most intense interest. Doubtless the present work has been published with a view of bringing before the general public those views which the author originally published in a much larger and a vastly more expensive volume. However that may be, we must express our gratitude to him for the pains he has taken in presenting us with a series of views which we believe were originally photographed by himself, and which therefore have a value far beyond what the mere pen-and-ink or pencil sketches of an artist would have, inasmuch as they are far more truthful. It is impossible to do more than give three or four quotations from this interesting work, which is written in a remarkably pleasant style, which possesses both accuracy of general statement and withal runs easily and smoothly to the ear.

Johore is one of the places visited by the writer, who describes it as separated from Singapore by a narrow strip of water, and in its wild forests we meet with a "type of man by far the most primitive that these regions have to show. These are the Jacoons, who, like the orang-outang or mias of Borneo, are reported to dwell in trees . . . They are said to be the true aboriginal inhabitants of the land. The pure specimens among them are woolly-haired and dark-skinned; the same sort of people, indeed, whom we

* The blocks have been kindly lent by Messrs. Low.

† "The Straits of Malacca, Indo-China, and China; or, Ten Years' Travels, Adventures, and Residence Abroad." By J. Thomson, F.R.G.S. London: Sampson Low & Co. 1875.

meet with in the Papuans of New Guinea, in the natives of many of the Pacific islands, and in the mountains of Indo-China . . . They detest the Malays, and hold no intercourse with them." Further we meet with the author's description of many curious habits and manners of the people of Siam. By the way, some of the writer's tales strike us with a doubt as to their accuracy, which we do not like to express more particularly; for instance, the story of the Siamese Prince and the foreign china-broker.

The Jacoons.*

However, we can pass over this, when there are so many facts of the greatest interest and of undoubted truth. What, for example, can be more wonderful to see in such a country than the Temple of Nakhon Wat? A wondrous temple, gigantic in point of size, symmetrical in all its parts, and yet completely different from the buildings of the population now existing. "The secret," says the author, "of my emotion lay in the extreme contrast between Nakhon Wat—rising, with all the power which the magnitude of proportions can give a sculptured giant pyramid, amid forest and

The blocks have been kindly lent by Messrs. Sampson Low & Co.

jungle-clad plains—and the grass-thatched huts . . . which are all that the present inhabitants have either wish or ability to set up. Nakhon Wat is raised upon a stone platform. It is carried from its base in three quadrangular tiers, with a great central tower above all, having an elevation of 180 feet. The outer boundary-wall encloses a square space, measuring nearly three-fourths of a mile each way, and is surmounted by a ditch 230 feet across. . . . Facing the cardinal points of the compass and in the

Interior of Western Gallery, Nakhon Wat.

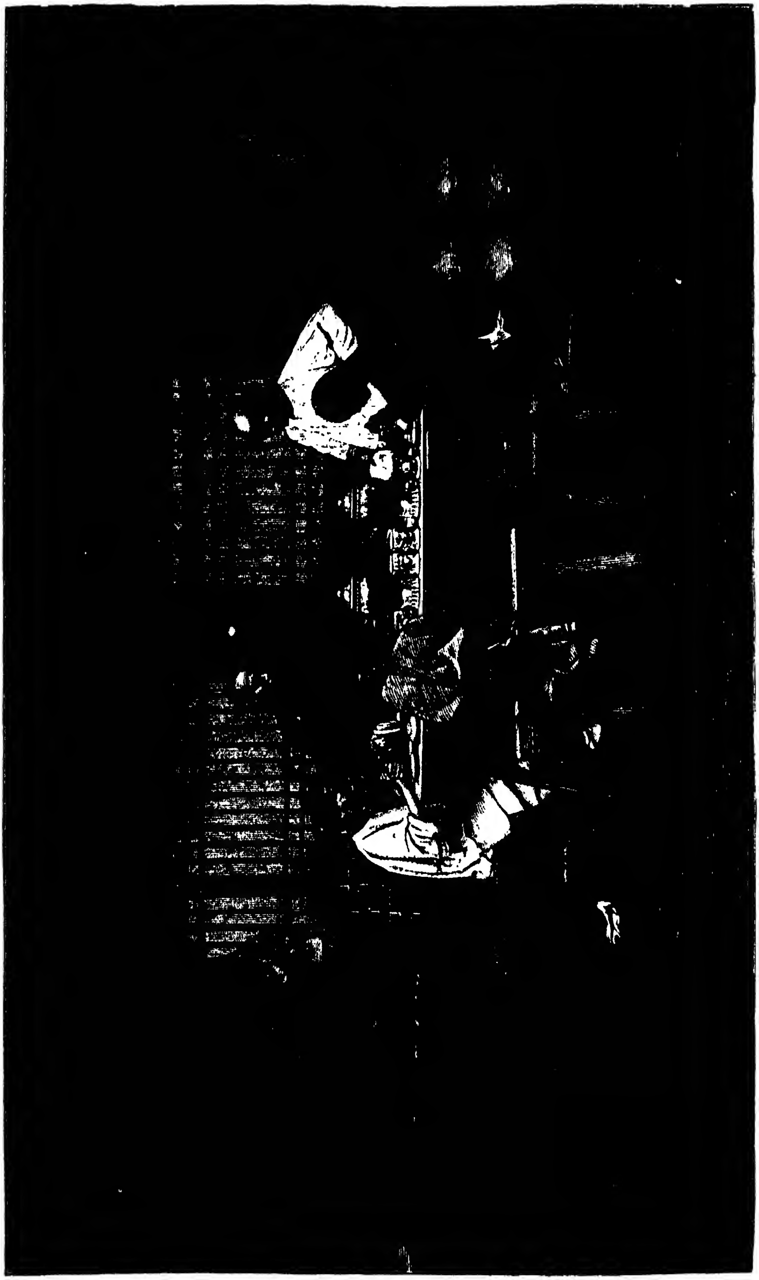
centre of each side of the boundary-wall there are long galleries, with arched roofs and monolithic pillars, which present a striking and clerical appearance," &c. And so on the author describes this wondrous temple, and he gives sketches of the drawings and sculptures that are within it. Some of these resemble many of those that readers will be perhaps most familiar with in Assyrian remains, and are works that could alone have been executed by an advanced and educated race.

Canton and Pekin are described by Mr. Thomson with the most wonderful minutiæ, and the numerous illustrations which accompany the accounts seem to impress the picture more vividly on the mind. Let us take one of the smaller sketches for example. It is that of a couple of residents of Shanghai who are, let us say, out shopping. "The substitute for the cart here is the wheelbarrow—a very undignified sort of conveyance, but nevertheless comfortable enough when one has grown accustomed to its use. It is pleasant to see the Chinese domestics and their families, or native ladies, dressed in silks, their glossy hair held in by a broad black velvet band, with a spray of pearls in front, being propelled along the land in their hand-carts. . . . There is not much risk in a steady-going vehicle like this. The coolie who propels it is neither skittish nor given to shieing, and the power he puts on is never dangerous." As regards their industry, too, the following page affords a good example.

The last matter we shall refer to is Mr. Thomson's account of the Peking Observatory. This he describes as a mixture of scientific instruments with others of a more mythic character. It was originally founded possibly in Marco Polo's time, and it has instruments of an antique date, and also some

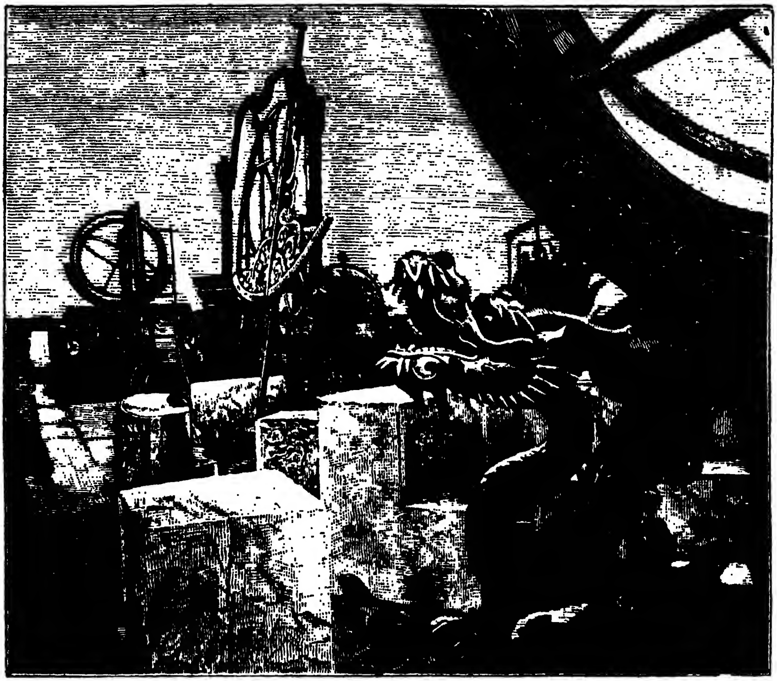
The Shanghai Wheelbarrow.

that were put up by the Jesuits in the seventeenth century. Mr. Wylie is, however, of opinion that they were put up by Ko-show-king, one of the most famous of Chinese astronomers. One of the instruments "is an astrolabe, furnished beneath with a splendid sun-dial, which has long since lost its gnomes. The whole, indeed, consists of three astrolabes, one partly moveable and partly fixed in the plane of the ecliptic; the second turning in a centre as a meridian circle; and the third the azimuth circle."



Making Enamel, Peking.

We have not done justice to this fine work; but if we have said sufficient to show how excellent an account it is of Chinese manners and of ancient



Peking Observatory: Jesuit Instruments.

Chinese architecture, we shall consider that we have discharged a debt which every reviewer owes to its author.

THE AERIAL WORLD.*

WHILE works upon any branch of natural history, or botany or geology which are written for the general public cannot have in them anything that is particularly novel, a book which treats upon the atmosphere may yet present many facts that appear even to the educated man perfectly new. And the reason of this simply is, that while natural history has been dealt with as a popular pastime—almost, we might say, since the time of Goldsmith—the facts of meteorology—that is, the more striking phenomena

* "The Aerial World: A Popular Account of the Phenomena and Life of the Atmosphere." By G. Hartwig, M.D., Ph.D. London: Longmans, 1874.

of the science—have never been put clearly before the general reading public. We are glad, however, that an effort has now been made to place the history of aerial science before the reader of popular works. And we may say at the outset that we consider that in discharging his task Dr. Hartwig has infinitely surpassed his former efforts in similar directions. Of the many popular works which this gentleman has given us we know of none that will compare, either for clearness of style or excellence of matter, with the present volume.

He tells us in his preface that he has avoided giving such a character to the book as "would be required in a handbook of meteorology." We think that in doing so he was actuated by most discreet motives; for assuredly a book which would have been simply a meteorological text-book would have been excessively dry in reading, while such a subject as that he has chosen forms, when properly discussed, a work which, once taken up, is very difficult to lay down. Indeed, we should like to give a full notice of this highly interesting work, for throughout its pages we find that facts are most carefully stated, and are invariably surrounded with a valuable discussion, which takes away the dryness which would otherwise have surrounded them. However, as we cannot do this, we may at least give the headings of the several chapters, as that will help the reader to form a somewhat independent judgment. First, then, is a chapter on the magnitude and pressure of the atmosphere, and then follow others, for nearly 550 pages, on the ingredients of the atmosphere; the propagation of sound through the air; echo; the colours of the sky; dawn and twilight; the temperature of the atmosphere; the winds; waterspouts, landspouts, tornadoes; fogs; dew; clouds: rain; the rainbow; the mirage, spectre of the Brocken, halos, mock suns and moons; snow, the thunderstorm; the means of preventing accidents by lightning; the cyclone; St. Elmo's fire; the ignis fatuus; hail; aerolites and shooting stars; the aurora borealis and australis; the primeval atmosphere; weather prognostics; the atmosphere and solid earth-rind; the atmosphere and ocean; the atmosphere and vegetable world; the aerial life of insects, birds, bats, and flying-fishes; influence of climate on man; flying machines; the balloon; the pleasures and perils of aerial navigation; the great Nassau balloon; scientific aerial voyages; and lastly, the balloon in war. Out of this vast selection of interesting chapters there is but one passage which we will quote. And this refers to those comparatively recent researches in geology that prove beyond the possibility of doubt that the temperature of Greenland must have been once even warmer than our own. Dr. Hartwig says, page 365: "At Anakerdluk, in North Greenland, in 70° N. lat., a large forest lies buried on a mountain, surrounded by glaciers 1,080 feet above the level of the sea. Not only the trunks and branches but even the leaves, fruit, cones, and seeds have been preserved in the soil, and enable the botanist to determine the species of the plant to which they belong. They show that, besides firs and sequoias, oaks and plantains, magnolias, elms, and even laurels, indicating a climate such as that of Lausanne or Geneva, flourished during the miocene period, in a country where now an almost perpetual winter compels even the hardy willow to creep along the ground. During the same epoch of the earth's history Spitzbergen was likewise covered with

stately forests, and poplars and plantains grew where now the fugitive summer scarcely gives birth to a few stunted herbs in particularly favoured situations." At this time Central Europe enjoyed a sub-tropical heat, and huge salamanders, tortoises, and apes were to be found abundantly. If we had space we should add another paragraph, on the subject of aerial machines, balloons, &c., which are most intelligently detailed, but we cannot. We see only one fault, and that, unfortunately, is in a book in which aerial travelling should have occupied a very large share of the author's attention —viz. that the subject of aerial navigation has been but imperfectly studied. The author does not appear to have been acquainted with our Aeronautical Society, and hence he has not read any of the several treatises that have been published by Mr. Wenham, and other members, upon the scientific grounds on which those who wish to work toward a practical end must necessarily labour. We trust to see this defect repaired in a succeeding edition; for although one of Mr. Glaisher's first trips is described, that is by no means exhaustive of British efforts. Still the book is, as we have already said, most creditable to its author, most interesting to the public, and, in illustration and topography, it is everything that could be desired.

ECONOMIC GEOLOGY.*

IT seems to us that Professor Page has hit upon a new vein in the present work, and one, too, which cannot fail to promote an extension of the arts and manufactures; while, if we look merely to the sale of his book, we may, in an anticipatory fashion, congratulate the publisher upon its issue. We say so because we are certain that, in setting himself to work at the field he has now explored, the author has rendered the ordinary journey of the worker infinitely shorter than it used to be. He has spared him that species of encyclopædic travelling which is at once so lengthy and so frequently unsatisfactory. We know of nothing in the shape of an English work in which the man who is working at geology can find the information which in the present book is clearly set out before him. And by the worker we by no means infer "the gentleman with the hammer," who is simply intelligently amusing himself during the summer vacation. We refer to the man who, whether he be an agriculturist, or an engineer, or an inspector of mines, or a glass or china manufacturer, or a whetstone-maker, or a searcher after mineral springs, is engaged in a careful study of the soil, to endeavour to obtain from it the particular rocks or liquids which are of importance in his trade. A careful student of Lyell, or Phillips, or Murchison, Jukes, or Ansted would fail utterly in the peculiar knowledge demanded by any one of the above. Yet it is exclusively such men as these, who are in search of the mines or other mineral products, who are unquestionably the makers of the immense wealth which this country possesses. Mr. Page has thus

* "Economic Geology; or, Geology in its Relation to the Arts and Manufactures." By David Page, LL.D., F.G.S., Professor of Geology in Durham University, College of Physical Science, Newcastle-on-Tyne. Edinburgh: Blackwood & Sons, 1874.

replied to their constant demands, and has produced a book which, in its first edition, may present a few failings, from the unquestionable novelty of the labours involved in its production, yet will, we doubt not, effect much good and save much labour to some, while opening a new path to others. The next edition will, we should think, soon have to appear, and then we shall expect a better lesson from its author. The book is divided into several chapters, and treats of the various subjects into which geology may be said to divide itself in a purely commercial fashion. Among these we would especially refer to the sections devoted to architecture, civil engineering, mining work, heat and light producing, grinding, fire-resisting, dyeing, heating, and other matters. In these will be found a whole host of matter which is not to be found readily elsewhere. We notice, too, that the author appends to each chapter a list of the more important works upon the subject to which it refers. The cuts are generally well-selected, but are not by any means numerous enough. Another suggestion we would make for the future edition, and that is, that some of the chapters should be made more thoroughly practical than they are. The book savours a little too much of the class-room; we would alter this as much as possible.

THE COMMON FROG.*

PROFESSOR MIVART, F.R.S., has here given us a popular book on the anatomy of the common frog, which is undoubtedly an excellent work of the kind. It is not popular in the ordinary sense of the word, but is so, in that technical wording is absent, except in the description of the figures, where it is absolutely necessary. Further, the woodcuts are ample, and they have not been spoiled by an absurd diminutiveness, as is not unfrequently the case. It is a subject not easy to deal with, and yet we think that Mr. Mivart has been most happy in discharging the task of teacher. The various groups allied to the frog are of course described, and on this subject some of the author's own views receive discussion. After the general account of the commoner variety of frogs comes the description of the different groups of anatomical facts. And we especially think Mr. Mivart is to be complimented on his treatment of the anatomy of the brain. This is dealt with comparatively fully, the figures helping the student to follow the points dwelt on in the text, and enabling him to contrast the brain of the frog with the brain of man in its earlier stages of development. The summary of the anatomical points in which a frog differs from fishes, reptiles, birds, and mammals is a capital addition to such a book.

* "The Common Frog." By St. George Mivart, F.R.S., &c. London: Macmillan & Co., 1874.

TYNDALL'S BRITISH ASSOCIATION ADDRESS.*

WE have received from Messrs. Longman a reprint of the British Association address of Professor Tyndall—an address which, from the fact that it was delivered in that hotbed of Low Churchism, Belfast, has been more unmercifully and less scientifically dealt with than perhaps anything written within the past ten years. It is especially of interest from the preface, in which the author replies to some of the more important of his critics. This we commend to all, as well worthy of being slowly and thoughtfully digested. We think that Professor Tyndall has yielded nothing to his opponents (as some supposed), but has expressed himself learnedly and clearly in defence of the tone adopted in this address.

THE ORIGIN OF CREATION.†

IT is with some surprise that we have seen so eminently distinguished a firm's name as that of Longman at the foot of the title-page of this work, and we can only account for it on the supposition that the publishers were utterly ignorant of the nature of the book at the period of publication. In any other acceptation of the circumstances, it is utterly impossible to forgive the issue of the work before us; for, to speak plainly, it is a conglomeration of the silliest nonsense it is possible to conceive emanating from any men of the faintest scientific worth. It is the most extravagant piece of composition we have almost ever seen written on a scientific subject; and again, it is written by men whose knowledge even of the rudiments of science is absurdly small, or we might better say absolutely *nil*. We shall only quote a couple of passages to show the melancholy ignorance of the authors of this work. Speaking, on p. 173, of coral, they say: "The title of this chapter may seem strange, as we have always been taught that coral *did not grow*,‡ but was designed and built by small *insects* . . . . . but it is our painful duty to inform naturalists generally that their eulogy is misplaced; that coral insects are no more to be compared to bees than sand is to sugar; and that they are as unworthy of notice as a common grub or fly." Again: "Coral is only a form of mineral growth, and it as surely grows in equatorial waters by natural law as a tree grows on the surface of the ground." After this we need not add a single syllable.

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* "Address Delivered Before the British Association, Assembled at Belfast." With Additions. By John Tyndall, F.R.S., President.

† "The Origin of Creation; or, the Science of Matter and Force. A new System of Natural Philosophy." By T. R. Fraser, M.D., and A. Dewar. London: Longmans, 1874.

‡ The italics are ours.

INSECTS ABROAD.*

WE have had various occasions of wondering at the marvellous industry which is exhibited by the author of the book before us; and we have had reason once or twice to condemn the tendency we saw displayed as approaching too nearly that of the mere book-maker. However, "Homes without Hands" and some other works served to increase our respect for the most popular natural history writer in our country; and we confess that on examining the present volume we are bound to say that in most respects it is a work which will add to its author's fame; it is also a most popular book, and its illustrations, which are of two kinds, plates and woodcuts, are most numerous, and lack nothing either in artistic worth or biologic excellence. The page-plates are twenty in number, and are most attractively drawn and scientifically correct, while the woodcuts, which are over 500 in number, are almost on every page of the work. Of course the insects described are all foreign, but they are of vastly more interest even than one whose taste is not for natural history would imagine. Let us see for a moment how the various groups are of importance as food. Bees of course furnish honey, but many of them are themselves eaten in a grub state in many countries, while bee-bread, as well as several wasps, are not considered unworthy food. Locusts, again, form food for various races, not only of man, but of beasts, birds, and reptiles. There is an article of diet among the Australian natives termed the "Bugong moth," and dragon-flies are also used by the same people. In Europe the wood-ant is used in the manufacture of vinegar, and also in the South of France is transformed into a certain sort of cream, called *crême aux fourmis*. Mosquitos are prepared as a sort of cake, called *kungo*, among the inhabitants of Nyassa lake, and the gru-gru grub of the West Indies is considered by those who have once tasted it (it is eaten alive) a most delicious morsel; a not less curious article of food is the egg of an insect which inhabits the fresh waters of Mexico, and which is made into cakes under the name of *haoutle*; while, lastly, there are the better-known instances of the blister-beetle, the cochineal insect, and the well-known manufacturer of "lac."

The classes of insecta which Mr. Wood adopts are the Coleoptera, Dermoptera, Orthoptera, Thysanoptera, Neuroptera, Hymenoptera, Lepidoptera, Hemiptera, Homoptera, and the Diptera, under each of which he gives ample instances of wondrous peculiarities of structure and habits, but it is more especially the case with the two groups of bees and beetles. From these, if space permitted us, we might select quotations almost without end, for the author not only gives his own account of each group, but supplements it with varied quotations from the works of the better-known authorities. However, there is one quotation — the last in this very interesting volume—to which we would take some exception; and we are the more sorry for this as it is a statement made by a brother of the author. It is as regards the well-known chigoe, or *pulex penetrans*. The gentleman

* "Insects Abroad; being a Popular Account of Foreign Insects, their Structure, Habits, and Transformations." By the Rev. J. G. Wood, M.A., F.L.S. London: Longmans, 1874.

we have referred to writes to his brother that a deal of rubbish has been said on this subject—that of the chigoe—and he mentions, of his own experience, that "during the past month there would be half-a-dozen at a time boring away and removed two or three times a day." He must surely be indeed "thick-skinned," if he has had so much trouble with these little pests, and has taken so little notice of them. However, we are aware that the chigoe is frequently an exceedingly annoying pest, and indeed is sometimes, if improperly extracted, the cause of extreme inflammation.

CAVE-HUNTING.*

A NEW book, on an entirely new subject, is that which Professor Boyd Dawkins has given to the scientific world. We may at least style it new, for it certainly is a novel subject to the present generation of readers, at least fifty years having elapsed since Dr. Buckland gave to the world his well-known and clever treatise, "Reliquiæ Diluvianæ." But it must not be imagined that it is new to scientific men, although it is certainly so to the public, for for some years the labours of the author, of Mr. Pengelly, Dr. Keller, Mr. Evans, Sir John Lubbock, Professor Lartet, Mr. Christy, Professor Huxley, and Mr. Busk have all been more or less devoted to the working out of the history of the so-called bone-caves in this country and abroad. Now, however, the time had come, in the opinion of the author, for making known, in a work devoted to the subject in its widest sense, the history, mode of exploring, contents, and geological aspects of the most important explorations that have been made by himself and others, at home and abroad. And in working out this view of the subject the author has, in our opinion, done well, and has produced a volume which, in point of importance and of general interest, must hold a place between Keller's "Lake Dwellings" and Lyell's "Antiquity of Man." We can but briefly state what has been the result achieved by the explorations which the author so well details. If further evidence were required than that obtained in America and Egypt of the antiquity of man, these bone-caves prove it beyond a possibility of doubt. But they prove more: they show us in great measure, taken with other evidence, what were the early races which lived in Europe and how they succeeded each other; and further, they prove that the climate of Europe was then vastly colder than it is now, as, of course, it once was greatly warmer than at present. These are important facts.

In dealing with these subjects the author has gone in detail into descriptions of the various caverns in Britain and the Continent, nearly all of which he has himself been engaged in the exploration of. It is to be regretted, however, that he has obtained such very meagre information regarding the

* "Cave-hunting: Researches on the Evidence of Caves Respecting the Early Inhabitants of Europe." By W. Boyd Dawkins, M.A., F.R.S., F.G.S., Curator of the Museum and Lecturer on Geology in Owen's College, Manchester. London: Macmillan, 1874.

caverns of Ireland, some of which—that, for example, at Dunmore, where so many human beings were destroyed by the cruelty of an English officer in days gone by—are vastly larger than any of the English caverns. But if we overlook this we certainly must admire the manner in which he has given and illustrated his account of the caves. More than 190 woodcuts are distributed over the book, and lend a considerable interest to what otherwise might prove to the general reader somewhat dry matter. The information in the appendix will be useful to intending cave-explorers, for it explains the various instruments that are of use to the cavern-hunter. More particularly do we think the statements on the subject of cave-rafts extremely valuable. The facts, too, as to the method to be pursued in the exploration of newly-found caverns we think very useful. One of the chapters of the work consists of a report of Mr. Busk's paper on the human remains from the cavern at Perthi-Chwareu, and this is a most instructive communication, from the very careful manner in which the various measurements have been recorded. Altogether we must wish the book every success, for it is a very good summary of the labours that have been achieved by one of the most laborious and highly qualified of the labourers.

ON MAGNETISM.*

THE author of the well-known treatise on "The Wave Theory of Light," Dr. Lloyd, of Trinity College, Dublin, has now produced as important a treatise on the subject of general and terrestrial magnetism. It would, of course, be entirely out of our province to criticise such a work, which comes from the very first authority on this subject. We have, however, great pleasure in announcing the book, and stating that mathematical readers will find it discusses fully the laws of this complex branch of physics.

THE MENTAL AND SOCIAL CONDITION OF SAVAGES.†

ASSUREDLY this was a difficult task to take in hand, for it involved, besides a wondrous amount of reading, a keen discrimination between what was reliable and untrustworthy, and eventually a very close power of reasoning to place the facts attained by the system of study in their proper order. In fact, the drawing up of such conclusions as Sir John Lubbock's was a task which we are sure must have taken him years to accomplish. And however we may object to some of the determinations he has drawn, we must bow to the natural honesty of purpose that appears displayed through-

* "A Treatise on Magnetism, General and Terrestrial." By Humphrey Lloyd, D.D., D.C.L., Provost of Trinity College, Dublin, formerly Professor of Natural Philosophy in the University. London: Longmans, 1874.

† "The Origin of Civilisation and the Primitive Condition of Man." By Sir John Lubbock, Bart., M.P., F.R.S. 3rd edition. London: Longmans, 1875.

out the entire essay. Of course, this being the third edition of the work, we shall not be expected to pass it in review before the reader. We may, however, just allude to one or two points in it which strike us as being of special importance. And these are the chapters on Marriage and on Language. Those which deal with the question of nuptial ties are of excessive interest, and they carry out the purpose intended by the author, that of showing us that almost all ideas of marriage, however differently the several bonds may be established, have yet a certain amount of unanimity among them, even if we compare our own system with that of the King of Ashantee, who "always has 3,333 wives." The chapter on the origin of the names Father and Mother are very well worthy of being studied; for they show us that about 150 different languages, exclusive of those derived from Sanskrit, have nearly the same names for the two parents. Indeed, on this subject, that of languages, the author points out many facts which show us that the habit of enumerating is one which exists to a very slight extent among savage races, some of whom, he mentions, are unable to count as high as ten, while others are absolutely reduced to counting two. He shows how universal is the habit of counting on the fingers, though he does not mention that our own Roman numerals are on the same principle, 1 2 3 4 being the four fingers, and 5 the V, which simply represents the hand extended, the four fingers being on one side, the thumb on the other; while in the same way, with the two hands up, from 6 to 9 are formed, and 10 is simply the two hands placed wrist to wrist. He states that "the Zamuca and Muysca Indians have a cumbrous but interesting system of numeration. For 5 they say, 'Hand finished;' for 6, 'one of the other hand;' that is to say, take a finger of the other hand. For 10 they say, "Two hands finished," or sometimes more simply, "Quicha," that is, foot, &c., &c. Perhaps one of the most interesting parts of this volume is the appendix, which contains the author's reply to the Duke of Argyle's speculations. In this Sir John Lubbock has cautiously expressed the fallacies of the Duke's arguments, and in a foot-note to the last page but one expresses himself in justifiable sarcasm on the somewhat anomalous position accepted by his Grace.

This is a book to be read only by the careful student, who will find that he is well repaid for the time expended in formulating some of the conclusions of the author.

ECLIPSES, PAST AND FUTURE.*

IF this work had been limited to eclipses, it would have met with our approval, as a useful book; though we fancy there are few who care much about partial eclipses visible in England at distant future dates. But the second half of the book spoils it. In dealing with celestial objects for a small telescope Mr. Johnson shows neither literary skill, nor clearness in explanation, nor originality of ideas. Moreover, one would suppose that others had done nothing in this line, so completely does Mr. Johnson ignore

* "Eclipses, Past and Future; with general Hints for Observing the Heavens." By the Rev. J. Johnson, M.A., F.R.A.S. Parker & Co., Oxford and London.

the literature of the subject. He theorises, indeed, occasionally, but in this feeble fashion:—"If we look at our maps we shall see the parts of one continent that jut out agree with the indented portions of another. The prominent part of Africa would fit in the opposite opening between North and South America, and so in numerous other instances. A general rending asunder of the world would seem to have taken place when 'the foundations of the great deep were broken up.'" He surpasses even this, however, when he says that "it may not be going too far to see in the stars α, β, and γ Arietis an emblem of the blessed Trinity." We think it is going a great deal too far, unless the writer's object were to raise a laugh. But, Mr. Johnson being a clergyman, this can hardly be the case.

THE TRANSIT OF VENUS.*

We have here two books before us, both dealing with that remarkable astronomical phenomenon, which, we have learnt from the papers of about three weeks ago, has been so well observed at most of the English stations. The two works are somewhat different, the one being a slight sketch of the subject, well done, of course, but still very popular; the other is a fuller account of the history of the phenomenon, and deals more scientifically with the entire question. The former is the account given by Professor G. Forbes; the latter is from the pen of that well-known and careful worker, Mr. R. A. Proctor, B.A., F.R.A.S. This work extends over 250 pages, and is very full on the subject of Transits, giving a minute account of these phenomena as they occurred in 1639, 1761, and 1769. Then there is a chapter on Transits and their Conditions, which enables the reader the better to comprehend that upon the present transit. Mr. Proctor discusses these under the heading of "Places for Observing the Early and Late Beginnings of the Phenomena," and "Places for Observing the Early and Late Endings"; and lastly, "Places for Observing the Greatest and Least Deviations." He approves of the fact that most of the astronomers adopted the Delislean as well as the Halleyan method.

Professor Forbes has not set himself so severe a task; still he has done his work admirably, and we doubt whether not a few readers will prefer his book to that of Mr. Proctor, through its easy, familiar style and the absence of all abstruse questions. Both authors discuss the question of the so-called "black drop," though we confess that neither seems to have hit upon the whole cause, though Mr. Proctor seems to have most nearly accounted for it. Mr. Forbes's account of the experimental mode of observing an artificial transit proposal by the Astronomer-Royal is full of interest. Both books will have to be read by the astronomer.

* "The Transits of Venus; a Popular Account of the Past and Coming Transits." By R. A. Proctor, B.A. London: Longmans, 1874.

"The Transit of Venus." By George Forbes, B.A., Professor of Natural Philosophy in the Andersonian University. London: Macmillan & Co., 1874.

THE DOCTRINE OF ENERGY.*

MR. D. HEATH has attempted to write a book which shall explain what is the nature of so-called energy, and how it is influenced by various conditions, extending so far even as physiology. But he has endeavoured to write such a book exclusively for boys of the class of the "6th form Boys of the Surrey County School." In this we think he has completely failed. That he has the knowledge we do not deny for a moment; but that he is capable of imparting it in such a popular form as Professor Tyndall or Professor Huxley would adopt, or indeed in a popular form at all, we very decidedly deny. The book is a good one, which may be read with advantage by students who are preparing for the London University. But for schoolboys we certainly do not think it is at all well adapted.

AUTOBIOGRAPHY OF DR. GRANVILLE.†

THIS not being a scientific work must be our only excuse for so short a notice. It is, in point of fact, not a book which should have come to us at all: still we cannot help saying that it has interested us so much that we were insensibly led on from page to page, till at length we determined to read the two volumes of which it consists. And we have been intensely pleased with the life, for it is a sort of sketch of the politics of the time; something, in fact, like a story of what Holland House must have been—a mixture of sociality and political matters of the most interesting character, and told in a brilliant, sparkling style. The work is one which those who are ignorant of the life of the last three quarters of a century should read. Then they will see how much a man who was really an Italian, though by association an Englishman, can be mixed up with the affairs of his century, though belonging to so humble a profession as that of medicine. Great credit is due to his daughter for the very laudable and somewhat reverential manner in which she has discharged her task of editor.

A YEAR'S BOTANY.‡

THIS little book we have carefully read, and we can commend it to the careful attention of all who are interested in the subject. It is

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* "An Elementary Exposition of the Doctrine of Energy." By D. D. Heath, M.A., formerly Fellow of Trinity College, Cambridge. London: Longmans.

† "Autobiography of A. B. Granville, M.D., F.R.S.; being Eighty-eight Years of the Life of a Physician, who Practised his Profession in Italy, Greece, Turkey, Spain, Portugal, the West Indies, Russia, Germany, France, and England." Edited, with a Brief Account of the Last Years of his Life, by his Youngest Daughter, Paulina B. Granville. 2 vols. London: Henry S. King & Co., 1874.

‡ "A Year's Botany: Adapted to Home and School Use." By Frances Anna Kitchener. Illustrated by the Author. London: Rivingtons, 1874.

evidently a book written by one who thoroughly understands her subject, and who has carefully studied Mr. Darwin's writings. Her language is clear and terse, and her illustrations (her own) are capital drawings, in which Nature is alone adopted. It is one of the best little books we have seen for a long time, and the appendix is a valuable addition.

The following works have been received, and, owing to the late period of their publication, will be noticed in the next number of the POPULAR SCIENCE REVIEW:—

"The Doctrine of Descent and Darwinism," by Oscar Schmidt, Professor in the University of Strasburg (King & Co., 1875); "Evolution and the Origin of Life," by H. Charlton Bastian, M.A., M.D., F.R.S. (London, Macmillan & Co., 1874); "History of the Conflict Between Religion and Science," by J. W. Draper, M.D., LL.D., Professor in the University of New York (Henry S. King & Co., 1875); "Reliquiæ Acquitanicæ," Part XV., Edited by T. Rupert Jones, F.R.S.; "Supplement to Harvesting Ants and Trap-door Spiders," by J. Traherne Moggridge, F.L.S., with Specific Descriptions of the Spiders, by the Rev. D. Picard-Cambridge (London, Reeve, 1874); "Prodromus of the Palæontology of Victoria," Decade I., by F. McCoy, F.G.S., Professor of Natural Science in Melbourne University (London, Trübner, 1874).

We have also received the following books:—A "Tract on Musical Statics," by John Curwen (London, Tonic Sol-fa Agency, 8 Warwick Lane, E.C.); the "Safe Use of Steam," by an Engineer (London, Lockwood & Co., 1874); the "Annual Report of the Smithsonian Institution (U.S.A.) for the Year 1872" (Washington, Government Printing Office)—this is an excellent volume, and contains, among other interesting matter, a "Eulogy on Ampère," by M. Arago, which extends over more than sixty pages, and is admirably written; "Synopsis of the Flora of Colorado, U.S.A.," by T. C. Porter and J. M. Coulter (Washington, Government Printing Office, 1874); "Tenth Report of the Board for the Protection of the Aborigines in the Colony of Victoria" (Melbourne, 1874)—a very interesting document; "Descriptive Catalogue of the Photographs of the United States Geological Survey of the Territories" (W. B. Jackson, Photographer); and "Bulletin of the United States Geological Survey, Nos. 1 and 2" (Washington, Government Printing Office, 1874).

SCIENTIFIC SUMMARY.

ASTRONOMY.

TRANSIT *of Venus*.—The great event of the last quarter was, of course, the transit of Venus on December 9—the most important astronomical event (in conjunction with the companion transit of December 6, 1882) of the present century. As we write news has been received from the greater number of the Northern stations and from a few Southern stations, and we may say in brief that Halleyan success is assured. But we shall not be aware of the full extent of the success attained by astronomers until we hear from the principal Southern stations, and especially from Kerguelen Land, where no less than four of the most important observing parties are crowded together. Before entering on a sketch of the results reported from various stations, we may remark that the Americans, who sailed in the *Swatara*, were unable to effect a landing at Crozet Island. Rough weather prevailed when they reached that island, the first station on their route, and after waiting some time, they were compelled to proceed, in order that the other observing parties might not be unduly delayed. The party intended for the Crozets therefore proceeded with the others, and eventually (it is reported) took up a post at Campbell Town (not Campbell Island, as at first stated), in Tasmania. It is now stated that the Astronomer-Royal urged the Americans to attempt a landing at Crozet Island, the very place which he rejected in November 1873, as inaccessible, ridiculing the idea of its being occupied. Credit is claimed for him on this score by his chief assistant at Greenwich; but as the Americans had but one chance of landing there, while England had much more convenient opportunities, and yet has two parties close by at Kerguelen Land, and none at the Crozets, we fail to see precisely how the claim for credit is made out. The value of the station, when first pointed out, was bluntly denied by the Astronomer-Royal. We may also mention that the French, after meeting with many difficulties, have effected a landing at Campbell Island and St. Paul's Island—these being two of that series of "inaccessible rocks, mere geographical myths," which excited the ridicule of the Admiralty authorities last year.

The news may be thus summarised:—

From the North-eastern Delislean region for observing accelerated egress we have as yet received no news. But as the Halleyan stations around the Japanese Sea have a second-rate value for this phase, we are assured that it has been efficiently observed, as will presently appear when we consider the

reports from Halleyan stations. It is to be hoped, however, that some of the English stations on the Sandwich Isles have had good weather.

From the South-western Delislean region for observing retarded ingress we have as yet no reports (up to December 15).

From the South-eastern Delislean region for observing accelerated egress we have favourable reports in the case of the only two stations whence intelligence has yet arrived. These are Melbourne and Hobart Town—the news from Adelaide being of small importance. At Melbourne, Mr. Ellery, the able chief of the Observatory there, reports complete success. At Hobart Town the American party had partial success, but took 113 photographs, and we may presume observed contacts. It is, however, just possible that they did not get both interior contacts, in which case the chief value of their results will consist in the determination of the position of the chord of contact.

From the North-western Delislean region for observing retarded egress we have both good and bad news. Unfortunately the bad news is more important than the good news. In brief, all the best stations for observing this phase had bad weather. These were the Russian stations over the region extending from the Caucasus over the south-western parts of Siberia. Here every observing party failed totally on account of clouds. At the following inferior though still excellent stations for this phase—Roorkee, Teheran, and places in North Egypt—a complete success was achieved. At Ispahan the German astronomers lost the inferior contact at egress through clouds, but secured several photographs. At Madras, Mr. Pogson failed almost wholly. The observations reported from Kurrachee, Indore, and Calcutta were probably rough, and if they have any value at all can only be useful as Halleyan observations; for the Delislean method requires very exact astronomical work for determining true local time, whereas if the duration of transit were fairly well observed at those stations the result will be of considerable value.

From Northern Halleyan stations, for observing lengthened duration, we have news of great successes; in fact, far better results than could have been hoped for even by the most sanguine of the Halleyan advocates. We may premise that recently, in speaking of the two methods, Sir G. Airy described the chance of obtaining a pair of Halleyan observations as $\frac{1}{16}$, the chance for each contact being $\frac{1}{2}$, whereas the chance of obtaining a pair of Delislean observations, similarly calculated, was described as $\frac{1}{4}$, similarly calculated. This line of reasoning (though not strictly exact) would be exceedingly strong as against anyone who had been so ill-advised as to recommend leaving Delislean regions unoccupied, but which is simply valueless as against the proposal not to leave unoccupied the available Halleyan regions. Well, we have from the Northern Halleyan stations, notwithstanding these overwhelming odds against them, most gratifying news. From Nertschinsk, the best of them all, the news comes of complete success, both interior contacts being observed, and thirty measurements of distance obtained with the fine heliometer at that station. From Port Possiet (on the western shores of the Sea of Japan) we learn that duration was observed and many photographs taken. At Wladiwostock and Nagasaki the whole transit was observed, and upwards of eighty-five photographs were taken by

the American astronomers. Moreover, upwards of 100 measurements of cusps were made at Nagasaki, besides many excellent observations of the meridian transit of the Sun and Venus. The French observations under Janssen were thus reported by the Astronomer-Royal, at the meeting of the Astronomical Society on December 11: "The weather at Nagasaki was magnificent: the transit observations in Japan were most successful. Observations of the contacts were made by revolving photographs. That is what we call Janssen's plan, and I suppose this report, though no name is sent, comes from Janssen himself: 'Fine telescopic images. No ligament. 'Venus seen over sun's corona.' That is a singular report, which we have not from any other station. It is what in our language we should call over the chromosphere, but I cannot say how much is included in the word 'corona.' 'Glass photographs and silver plates.' I call attention to this because the expression is rather obscure to many of the younger Fellows of the Society. Glass photographs are common; but silver plates are only known to those who remember the original daguerreotypes, and it is apparently to them that reference is made: and it is important when we remember that in exactness there is no comparison between a glass plate and a daguerreotype, the latter being infinitely more accurate. The telegram continues: 'Cloudy at intervals; two members of our mission have made observations successfully at Robe.' I cannot say what this news is; it is one of the difficulties in which telegrams frequently leave us."

The admission relating to the superiority of daguerreotypes over glass photographs is noteworthy, as is pointed out in the excellent series of reports in the "Times" (by Mr. Lockyer, we believe), for the use of glass photographs by the British parties was specially sanctioned by the Astronomer-Royal. Success was also achieved at several other Russian Halleyan stations. At Roorkee, in North India, fine weather prevailed throughout; and besides observations of all the contacts, upwards of 100 photographs were secured.

The Southern Halleyan observations as yet reported are those made at Melbourne and Hobart Town. Professor Newcomb considers that the American work at Hobart Town, combined with that accomplished by the American parties at Wladiwostock and Nagasaki, will suffice to give the solar parallax within the fortieth part of a second of arc.

As we write we hear news of the successful observation of the transit at Chefoo (or Tschifu), in North China, by the German astronomers stationed there. As they have made good heliometric observations and secured good photographs, this is an important Halleyan success.

Latest Intelligence, to Dec. 26.—We regret to have to announce the complete failure of the English party in New Zealand, almost nullifying the Egyptian success. The Americans in New Zealand secured the chord of transit by photographs, but missed egress. At the Sandwich Isles partial success was achieved by two parties, Honolulu and Atooi, though the Janssen photographic method failed. Barnacle and Forbes, at Owhyhee, saw nothing. At Réunion the Dutch had only partial success.

Solar Parallax from Observations of Flora.—Dr. Galle writes thus from Breslau to the Astronomer-Royal: "As I availed myself of your kindness last year, in recommending that observations should be made of the planet

Flora, in the Southern hemisphere, with the view of using the same for a determination of the value of the solar parallax, I could not omit briefly to inform you that these observations have been carried out accordingly, and have furnished a very satisfactory result. Thanks to the co-operation of three Southern Observatories (Cape of Good Hope, Melbourne, and Cordoba), and nine observations in the Northern hemisphere, there have been so many corresponding observations, that results for the parallax could be obtained from forty-three different comparison-stars. The mean differs very little from the Mars observations of 1862, and from the result of Newcomb ($\pi = 8''\cdot 85$). The definitive result, however, cannot be assigned for some months, on account of a number of discordant observations, in regard to which some inquiries must be made of the observers." *

Proposed Observatory at Bogotà, South America.—M. Gonzalez, Director of the National Observatory of Columbia, has announced his intention to establish a Physical Astronomical Observatory at Bogotà, the capital of that state, at an altitude of about 3,000 mètres above the level of the sea, and in latitude 4° 33′ N. On account of the transparency of the atmosphere, M. Gonzalez believes that this observatory will be most favourably situated for delicate observations, such as the spectrum analysis of the heavenly bodies, especially of the Sun, the Zodiacal Light, &c. He intends to give up the direction of the National Observatory, so that he may be able to devote his whole attention, free from the control of the Government authorities, to this peculiar class of physical observation. M. Gonzalez expressed a desire that his private observatory might be considered as, in some measure, a dependence of this Society and the British Association, and he would therefore be happy to receive any suggestions from the leading Fellows as to the best means of utilising the observations which he hopes to make in such an exceptionally elevated locality. He is most desirous to carry out any recommendations he may receive so far as his resources will permit.

Satellites of Uranus.—Professor Holden, of the Washington Observatory, after confirming by observations with the great 26-inch telescope the elements assigned by Mr. Lassell to the two inner satellites of Uranus, has been at the pains to trace back the motions of these bodies, in order to see if either of them had been seen by Sir W. Herschel. He finds reason to believe that Herschel saw both Ariel and Umbriel, and "was in truth the discoverer of Ariel and Umbriel, as well as of Titania and Oberon, but that he was unfortunately prevented from identifying the inner satellites because his telescope could not show them on two successive nights." On this Mr. Lassell, entering "on self-vindication reluctantly and even painfully," as recognising that "egotism is essentially ungrateful," remarks: "I myself claim to be the original and only discoverer of these inner satellites, single-

* It appears from Dr. Galle's paper in the "Astronomische Nachrichten," No. 2012, that the result obtained from the whole of the forty-three stars is $8''\cdot 923$. He proposes to omit all the observations where the discordance exceeds $0''\cdot 75$, which would give $8''\cdot 858$ as the resulting value for the solar parallax from a comparison of the observations of the planet and thirty stars (fifteen in each hemisphere). This selection, however, is at present quite arbitrary.

handed and unassisted, without coadjutor, rival, or competitor." He gives reasons for questioning whether Sir W. Herschel really saw the inner satellites. It can surely make little difference, so far as Mr. Lassell is concerned, whether Sir W. Herschel saw them or not. Lemonnier and Flamsteed saw Uranus long before Herschel did, but Sir W. Herschel's credit is in no sort affected by the circumstance.

Present State of M. Delaunay's Investigations on the Lunar Theory.—Professor Simon Newcomb states that "Delaunay's two published volumes form a substantially complete work, so far as the problem of three bodies is concerned. It remains only to add the terms due to the motion of the earth round the common centre of gravity of the earth and moon, which is a simple matter. In the preface to the second volume Delaunay promised a third volume, to contain the investigation of the other actions to which the moon was subjected, in the spring of 1871. I learned from him that he had done substantially nothing towards preparing this volume, except to compute the secular acceleration. The result of this was published in the 'Comptes Rendus.' He was so much occupied with observatory management during the remainder of his life, that I feel confident he did little or nothing in addition. Last summer all his theoretical investigations were at the Observatory of Paris in charge of M. Loewy, who was desirous of continuing them. So far as the perturbations due to the action of the sun were concerned his tables were completed in 1871. It remains not only to finish the supplementary researches and tabulate the results, but to investigate the lunar elements, and to form the arguments of the tables. This work had not then been taken into consideration, and so far as I know was not commenced at all before his lamented death."

Relations between the Motions of some of the Minor Planets.—Professor Kirkwood, of Bloomington, Indiana, in a letter to Mr. Proctor, says: If your theory of planetary accretion be true, the zone of asteroids must probably furnish instances of special relations between the mean motions of its different members. I refer to such relations as those found by Laplace between Jupiter's first three satellites. Soon after your brief visit to Bloomington in March, I commenced comparing the mean motions of certain members of the group with those of Jupiter and Saturn. The research has already been crowned with success. My results, in part, are as follow:—

Let n^{v}, n^{vi}, represent the mean motions of Jupiter and Saturn; $n^{(50)}$, $n^{(78)}$, &c. those of Pales, Diana, &c.; the numerals in parentheses denoting the minor planets in their order of discovery;

Let also $L^{(50)}$, $L^{(78)}$, &c. represent the mean longitudes at a given epoch; then

$$n^{(50)} - 3n^{(78)} + 2n^{(11)} = 0 \quad . \quad . \quad . \quad (1)$$

$$L^{(50)} - 3L^{(78)} + 2L^{(11)} = 180^{\circ} \quad . \quad . \quad . \quad (2)$$

The exact similarity of these equations to those of Laplace, referred to above, is at once apparent. The origin of the relation, whether we accept the nebular hypothesis or your own theory recently announced, may be accounted for as in Note 7, vol. ii. of Laplace's "System of the World." But were the relations expressed by (1) and (2) rendered rigorously exact

by the mutual attraction of Pales, Diana, and Parthenope? This, to myself, seems wholly improbable. The required explanation is to be looked for in the perturbing influence of Jupiter and Saturn. A comparison of mean motions gives the following equations:—

$$2n^{(11)} - 9n^{\mathrm{v}} + 7n^{\mathrm{vi}} = 0 \quad . \quad . \quad . \quad . \quad (3)$$
$$n^{(50)} - 3n^{\mathrm{v}} + 2n^{\mathrm{vi}} = 0 \quad . \quad . \quad . \quad . \quad (4)$$
$$n^{(78)} - 4n^{\mathrm{v}} + 3n^{\mathrm{vi}} = 0 \quad . \quad . \quad . \quad . \quad (5)$$

Eliminating n^{v} and n^{vi} from (3), (4), and (5), we obtain equation (1).

Other results have been reached, which will probably soon be published.

The Zodiacal Light.—Mr. Plummer, having been engaged observing Comet III. 1874 (Coggia's) upon several occasions during the early morning hours in the present and preceding months, has noticed repeated brilliant exhibitions of the zodiacal light. Upon seven mornings it has been very conspicuous indeed, more than rivalling the brightness of the Milky Way, namely, on September 17, 19, 21, 22, October 9, 19, and 21, at hours varying from 14h. 15m. in the former month, to 16h. 0m. in the latter. On October 10 it was invisible only in consequence of a general phosphorescent state of the sky. "As these were the only dates," he says, "upon which I had the opportunity of observing the phenomenon, it appears to justify the conclusion that it has been much more distinct and brilliant this autumn than is usually the case. This confirms a precisely similar opinion which was forced upon me during the spring of the present year, and which I had already communicated to several astronomical friends. It is the more important, as a like period of maximum brilliancy appeared from my own observations to have taken place about the spring of the year 1866; which, if correct, would seem to indicate a periodical variation of brightness that has not been previously noted. I am induced to call attention to the matter, as it is not unlikely that the ensuing spring may also be a favourable season for observing it. I may mention that I have long watched with interest for the annual manifestations of the zodiacal light; and although my remarks thereon are scattered through the notebooks of different observatories, the above suspicion, which is founded upon them, may lead to more attention being paid to it than formerly. If Southern localities are more advantageous for the spectroscopic examination of the zodiacal light, there seems no reason why variations of brilliancy, supposing such to occur, may not be observed in England. Indeed, after making allowance for the want of purity of our atmosphere, and to some extent also for the greater duration of twilight, there would seem but little reason why the zodiacal light may not be as well observed here as in subtropical regions. As Colonel Tomline's observatory will be furnished with spectroscopic appliances before the next apparition of the zodiacal light, I shall not then fail to give the subject careful consideration in each of these aspects."

BOTANY.

The Mutability of Microscopic Germs.—On the 16th of November last M. J. Duval presented a note to the French Academy on the above subject, in which, referring to his former paper in the "Journal de l'Anatomie" for September 1874, he states that he has found a means of explaining both the doctrines of the panspermists and the heterogenists. And this explanation lies simply in the statement that he has discovered that the various so-called minute organisms (such as ferments) are simply one and the same organism, which has the power of becoming differently developed. He says thus: "A trace of alcoholic yeast sown in media chemically appropriate has given birth to *lactic*, *benzoic* and *ureic* fermentations, and in every case I found the formation of a new special yeast for each fermentation. The transformation of yeasts into one another is then possible, and it happens from all the evidence of these facts that the specificity of action of different ferments is a purely relative phenomenon dependent rather upon the composition or the state of the media than upon the proper constitution of these same organisms." The paper from which this is taken is an extremely interesting summary of this author's views, but it is in the essay in the "Journal de l'Anatomie" that the evidence in favour of it is to be found.

The Carpellary Theory applied to the Liliaceæ and Melanthaceæ.—M. A. Trécul, one of the best physiological botanists in France, has been recently discussing the above theory, which he considers applicable to the two orders there given. He thinks they give new examples of the various modes of nervation which he has formerly described, especially in treating of Ranunculaceæ. He considers that they confirm the conclusion he has formerly arrived at. He enters on an interesting classification of the pistil and fruits of these plants, for which we must refer our readers to the memoir itself ("Comptes Rendus," t. lxxix., No. 20).

Sphæraphides in Plants.—On this subject a paper of some interest appears in the "Monthly Microscopical Journal" for December 1874. The author states that in *Urtica dioica*, *U. urens*, and *Parietaria diffusa*, the leaf-blades are studded with sphæraphides, each about $\frac{1}{532}$nd of an inch in diameter, globose, smoothish or granular on the surface, and all composed mainly of carbonate of lime. In the fibro-vascular bundles of the leaf are chains of much smaller sphæraphides, each about $\frac{1}{1000}$th of an inch in diameter, rough from projecting crystalline points on the surface, and composed of oxalate of lime; and in the pith these small rough sphæraphides are still more abundant. Both the leaf and pith of *Humulus lupulus* abound in like manner with the two kinds of sphæraphides. In the leaf-blade these are crystalline concretions, made up of glassy granules, consisting of carbonate of lime. In the leaf-nerves, and in the pith of the stem, are thickly-set strings of rough sphæraphides, in shape and chemical composition like those in the same parts of the nettles and pelletory.

The Veins of Beech and Hornbeam Leaves.—Mr. Thomas Meehan, in a paper lately read before the Academy of Science of Philadelphia, said that De Candolle had noticed some years since a difference in the venation between the *Fagus ferruginea* and *Fagus sylvatica*, the common American and

European beeches. In the American beech the lateral veins were said to terminate in the apex of the serratures—in the European they terminate at the base of the sinus. He had not read the original paper of De Candolle, but abstracts in the scientific serials. As the statement stood, it conveyed the idea that there was a marked difference in structure between these two allied species which did not, however, exist, as growing in this country the leaves of the European beech are almost entire; the lateral veins, in approaching the margin of the leaves, curve upwards, and connect with the lateral above them, forming a sort of marginal vein near the outer edge of the leaf. The veins of the American beech curve upward in the same way, but are early arrested, and this sudden cessation of growth produces the serra, which are slightly curved upwards. An early arrestation of growth in the veins makes the serratures, and constitutes the only difference between the two species. The structural plan is the same in both—the European, curving its lateral vein into the apex, reached the upper one—the American terminating abruptly.

Botany of the American S. Pacific Exploration.—We learn from our contemporary the "American Naturalist" that since the lamented death of Dr. Torrey, his report on the Botanical collections made by the naturalist of Wilkes's expedition on our western American coast, has been printed under the care of Prof. Gray. It makes the larger part of the 17th volume of the results of that expedition, of which, like the rest, only 100 copies are printed by Congress. A small number of extra copies have, however, been secured, at private expense; these are bound up with the preceding part of the volume, devoted to the Lower Cryptogamia of the expedition (Lichens, Algæ, and Fungi), and, the large plates being folded and bound in, the whole makes a stout royal quarto volume, with twenty-nine plates. The Naturalists' Agency has this on sale, at ten dollars. The mosses of the same expedition by Sullivant, which form the first part of this same volume in the government copies, in the extra edition have the letter-press made up into imperial folio pages, in double columns, to match the twenty-six great folio plates. A very few copies of this handsome volume still remain in the hands of the late Mr. Sullivant's executors, and can be had for ten dollars each.

Poisonous and Innocuous Habits of the Flowers of Wistaria sinensis.—It seems that there is a popular belief that the flowers of the *Wistaria sinensis* are destructive to bees. Mr. Meehan recently stated to the "Philadelphia Academy of Science" that he had himself seen hundreds of dead bees under large flowering plants. He was struck with the fact this season, that none were dead under similar circumstances. The flowers were continually visited by the honey bee, and others, without, so far as he could see, any fatal results following. It was clear, therefore, that, whatever might be the cause of the death of these insects under some circumstances, it could not be from the honey alone.

A Fly-catching Plant.—Many instances have been afforded—following the remarkable facts adduced by Mr. Darwin—of the insectivorous character of certain plants. Now Mr. W. W. Bailey has come forward ["American Naturalist," No. 9 vol. viii.] with some remarkable facts concerning the American sweet swamp azalea (*Azalea viscosa*). He says: "I have been

amusing myself, if any such apparently cruel occupation can be considered entertaining, in watching the capture of flies by the azaleas. When I first brought the flowers home, many small insects, as winged ants, were entrapped amidst the hairs. These have remained alive several days, still vainly struggling for freedom. As the houseflies are abundant in my room, it occurred to me that I might extirpate the pests, and at the same time learn something of the process of insect-catching. I exposed a number of buds and fully opened blossoms on a sunny window-sill thronged with flies. It was not many minutes before I had several captures. A mere touch of a fly's leg to the glutinous hairs was sufficient for his detention. A struggle only made matters worse, as other legs were by this means brought in contact with the glands. These emit long glairy threads which fasten to the hairs of the flies' legs. They may be drawn out to a great length and tenuity, still retaining their strength. Under the microscope, the legs of the fly are seen to be covered with the secretion, which is perfectly white and transparent. In one attempt to escape, a housefly lifted a flower bodily from the window-sill, perhaps a quarter of an inch, but at once sank back exhausted amidst the hairs. In one instance, I have found the dried remains of a small insect embedded amidst the hairs, but cannot say whether its juices were in any way absorbed by the plant.

CHEMISTRY.

Marsh's and Reinsch's Tests for Arsenic combined. In the "Transactions of the Royal Society of Victoria, New South Wales" [vol. x. 1874], which we have just received, there is a paper by the Rev. William Kelly, S.J., in which he explains a method which had suggested itself to him, by which Marsh's test and Reinsch's could be immediately combined, so as to ascertain and guarantee the absolute purity of the testing reagents, and to make the two great tests immediately corroborate each other. He relied on the well-known fact that the copper of Reinsch's test is entirely dissolved in presence of Chlorate of Potassa, and pointed out that this action, which is often treated as an objection to the test, may be made to confirm it. If a portion or the entire of the copper thus completely dissolved be introduced into Marsh's apparatus, it will produce the characteristic clouds, spots, and stains; the troublesome frothing incident to organic substances being entirely avoided. Pieces of porcelain and glass showing the results of experiments were handed round. The reverend gentleman explained in detail many of the advantages which would arise from this combination, which he believed had not been suggested in any of our toxicological treatises.

The Manufacture of Otto of Roses.—In the "Moniteur Industriel Belge," which is quoted by the "Scientific American" [October 10, 1874], is an interesting article on this costly perfume, which says that the manufacture is largely carried on in the valley of Kesanlik, Roumelia, the annual production of the rose farms of which amounts to 4,400 pounds of the otto per year. As it requires about 130,000 roses, weighing some 57 pounds, to make an ounce of the oil, some idea of the extent of the plantations may be

formed from the above given total. The flowers are gathered in the middle of May, and the harvest continues for three weeks. The blossoms collected each day are at once worked, in order that none of the odour may be lost. The process consists in distilling them in water, and then causing the water alone to undergo distillation, when the oil is skimmed from the surface. The labour is principally done by women and children, at wages of about ten cents per day. The otto is always adulterated, before transmission to market, with one-third or one-fifth its quantity of geranium oil.

Zinc precipitated by Water.—It seems from a letter by Mr. J. L. Davies, in the "Chemical News" [October 2, 1874], that zinc may be added to the list of metals which can be precipitated by means of water. The conditions seem to be these. If to a solution of zinc chloride, just sufficient *only* of ammonia be added to re-dissolve the precipitate at first formed, the addition of water throws down zinc in the form of a gelatinous and bulky precipitate. In the cold the whole of the zinc is not thus precipitated, but possibly with continued boiling it might be.

An Improvement of the Bunsen Burner for Spectrum Analysis.—Mr. F. Kingdon, Assistant in the Physical Laboratory of Owens College, read a paper before the Manchester Literary and Philosophical Society [Nov. 2, 1874], in which he said that the students in the Physical Laboratory of Owens College having occasionally experienced some difficulty in obtaining the spectra of some salts with the ordinary Bunsen, through apparently a deficiency of pressure in the gas, it occurred to him that the amount of light even at this deficient temperature might be increased by multiplying the number of luminous points. This is accomplished by broadening out the flame of the Bunsen, that is, causing the gas to issue through a narrow slit, instead of a round hole. He has, so far, only made a rough experiment, the slit being about $\frac{3}{4}$ in. long and $\frac{1}{8}$ in. wide. The result is, as expected, a more brilliant spectrum.

Formation of Red Vapour during Sugar-boiling.—In the "Chemical News" of Oct. 30th, 1874, M. E. J. Maumené states that he has observed an extraordinary evolution of red vapours at the moment when the air-pumps of the vacuum pans began to work, and at nearly all stages of the operation. There is generally a notable amount of nitrates in the juice of the beetroot. M. Maumené finds that sugar may be the cause, or one of the causes, of the formation of these red vapours. Whenever the juices contain nitrate of ammonia, their decomposition is imminent. This is certainly one of the most active causes of discolouring the boiled mass, and of molassification in the last stage of the boiling process. The ammonia may be expelled by lime. The juice mixed with lime and water is considerably ameliorated if allowed to stand for twenty-four hours.

Bismuth Bromide.—This rather novel substance has been recently written on by Mr. R. W. E. Macivor, who states that the combination of metallic bismuth with bromine to form $''Br'''Br_3$ is not, as is the case with antimony and arsenic, attended with the emission of light. The compound is prepared by heating finely-powdered bismuth with dry bromine in a hand-glass tube closed at the end. Bismuth bromide, as obtained by this process, is a solid substance of a dark grey colour, fusing at a temperature of 198° to 202° C. to a dark red liquid which boils below a dull red heat. It is insoluble in

carbon disulphide, alcohol, and ether. Hydrochloric acid dissolves it. By heating with nitric acid it is decomposed. It absorbs dry ammonia gas, with formation of a black non-crystalline solid body possessed of an extremely irritating smell. On exposure to the air, it absorbs moisture, and becomes of sulphur-yellow colour. Upon treatment with water it is decomposed, the products of the action being a white amorphous oxybromide and free hydrobromic acid. The oxybromide is insoluble in a solution of tartaric acid, and is decomposed on subjection to a long-continued process of washing with water, with formation of hydrobromic acid and bismuth oxide ($''Br_2''O_3 + \chi Aq$).—"Chemical News," Oct. 23rd.

How to produce Photographic Proofs on Wood.—"Les Mondes" of Sept. 24th, gives the following mode as that of M. F. C. Roche: The block of wood is first covered with a layer of gelatin (0·39 grm. to 31 grms. of water) by means of a soft brush. When this coating is dry it is covered, in the dark, with a solution prepared of—(1) Red prussiate of potash, 7·80 grms.; water, 62·20 grms. (2) Ammonio-citrate of iron, 9·10 grms. in 62·20 grms. water. These solutions are mixed and filtered, and the mixture is kept in the dark. When the layer is dry it is exposed under a negative for ten to twelve minutes, and washed with a soft sponge, when a blue image appears. If thus prepared the coating does not shell off under the graver.

The natural Formation of Nitrous and Nitric Acid, and Peroxide of Hydrogen.—M. L. Carius states that ["Chemical News," Nov. 20th] oxides of nitrogen may conceivably be formed from free nitrogen by electric discharges in the air during the oxidation of other bodies in the air; oxidation of nitrogen by means of ozone, and formation of nitrite of ammonia by the evaporation of water in the air. The author finds that the two last-mentioned phenomena are not attended with the production of nitrous or nitric acids. These acids may also be supposed to be formed by the oxidation of ammonia, whether caused by electric discharges, by the presence of alkaline bodies, or by ozone. Experiment showed that the acids in question are actually formed in all these cases.

Alteration of Coal by Exposure to moist Air.—M. Varrenstrass finds that the loss of weight due to slow oxidation, and to the escape of gases rich in carbon, may amount to one-third of the original weight. The calorific power sustains in this case a loss of 47 per cent. In closed store-houses the loss of weight was only 25 per cent., and that of heating-power 10 per cent. Bituminous coals undergo the most rapid alteration.

The Colour of Chloride of Copper.—Mr. W. N. Hartley lately [Dec. 3rd] read a note on this subject before the Chemical Society. He finds that the crystals of cupric chloride, $CuCl_2, 2OH_2$, which are generally described as green, are really of a pale blue tint when rendered quite free from adhering moisture by exposure *in vacuo* over sulphuric acid. The green colour of the crystals, as ordinarily seen, he considers to be due to their being moistened with a film of the deep green solution of the salt. When examined by the dichroïscope, the light through the principal axis shows one image of an azure blue, and the other of an emerald green.

The Way in which Coal is Formed.—"Les Mondes," of Sept. 24th, states that M. Hirschwald, on visiting a gallery in the Clausthal mines, abandoned for 300 to 350 years, found some wood which had been left there.

It had absorbed the waters which flowed in the interstices of the schists, and had become of a brown colour and coriaceous texture. On exposure to the open air it quickly hardened, and was completely transformed into brown coal (lignite) with a conchoidal fracture. Its percentage of carbon was very similar to that found in the best Saxon lignites. This observation shows that the circumstances favourable to the natural carbonisation of wood are—(1) Situation among fragments of rocks among which circulate freely subterranean waters impregnated with metallic salts. (2) A constant and relatively elevated temperature, such as prevails in deep excavations. (3) Continuous pressure.

Chemical Nature of Animal Substances which produce a Cross under the Polariscope.—In the "Comptes Rendus" for Nov. 9th appears an interesting paper on the above subject by MM. Dastre and Moral. In the yolk of the eggs of birds are found spherical corpuscles presenting, when examined under the polariscope, a cross whose limbs enlarge as they diverge from the centre. M. Dareste, who discovered these bodies in 1866 in the eggs of birds, has since found them in other animals—tortoises, osseous fishes, &c., and in various parts of the organism. R. Wagner has found them in the *vesiculæ seminales*, and M. Balbiani in the adipose body of the silkworm. M. Dareste considered them as animal starch, and believed that he had transformed them into glucose, making use of this supposed fact as an argument against the localisation of the glucogenesis in the liver. The researches of the authors prove that these bodies consist of lecithine, a nitrogenous and phosphorised principle made known by Gobley. It is interesting to find a nitrogenous matter—considered as amorphous, and of a viscid and colloid nature—present a great number of the essential properties of crystals, assuming constantly a regular and symmetrical geometric figure. Lecithine is very distinct from starch; it is not turned blue by iodine; it dissolves in alcohol, and is precipitated by water, whilst the behaviour of starch is quite the reverse. The polarisation-cross being, therefore, not peculiar to starch, its value in proximate organic analysis is not greater than that of an ordinary crystalline form.

GEOLOGY AND PALÆONTOLOGY.

Coral Reefs of Hawaii.—A note of some interest appears on this point in "Silliman's American Journal," for Dec. 1874. It is by Mr. J. D. Dana, the well-known coral explorer, and it is as follows: Mr. Darwin, in the new edition of his work on Coral Reefs, cites statements from Ellis respecting the existence of elevated beds of coral detritus "round several parts of Hawaii, about twenty feet above the level of the sea." The writer, as Mr. Darwin states, saw hardly any reefs about the island, the only point mentioned in my report being the vicinity of Hilo. In reply to an inquiry by me on the subject, the Rev. Mr. Coan, long a resident of Hilo, and, as missionary, a traveller over various parts of the island of Hawaii, makes the following statement in a letter dated Hilo, October 26th, 1874. Mr. Coan is a careful observer of natural objects and phenomena, and has written much on the Hawaiian volcanos: "With respect to your inquiry whether

there is any elevated coral reef rock around the shores of Hawaii, I would reply that I think not. I have travelled the whole circuit of the island by land, and in boats, canoes, and larger vessels, and there is hardly a point along the shores which I have not noticed carefully. Honolulu, on the island of Oahu, is built much of it upon the elevated coral reef rock, and there are large areas in the district of Waianæ and other portions of the Oahu shores; but there is nothing of this kind on Hawaii. You are aware that corals, even under the water, are on the weather side of this island [the eastern, near the middle of which is the harbour of Hilo], not abundant, and all the good specimens we get are obtained by diving. Small quantities of broken corals are washed ashore by the waves." The Oahu reefs are described by me in my Exploring Expedition Geological Report, pp. 251–256. The facts are more briefly mentioned in my work on "Coral and Coral Islands."

How is Flint formed, and how does it operate in Fossilisation?—These are two questions which have not yet been satisfactorily considered, especially the latter one. However Dr. O. Ward has attempted an answer in a paper, read Nov. 20, 1874, before the Eastbourne Natural Hist. Soc. After discussing the mode of experimenting performed by Dr. Richardson, he says: "These discoveries and experiments of Dr. Richardson seem to me to be likely to throw great light upon several geological facts not hitherto explained. First, they explain how flints may be formed and deposited upon organic substances: next they explain the greater hardness of the matrix immediately enveloping fossils; thirdly, they account for fossils being so frequently found in the centre of a nodule, the materials of which are arranged in concentric layers; lastly, they explain the absence of fossils from metamorphic rocks; for if we can destroy nearly all traces of organisation in a few hours, and with a low temperature of 340 degrees F., there can be no difficulty in understanding how rocks full of fossils may entirely change their character, and chalk or tertiary limestone be converted into marble of a perfectly homogeneous appearance in contact with lava and other igneous products as are found at the Giant's Causeway."

A Phonolite from the "Wolf Rock."—Mr. S. Allport again refers to this subject in the "Geological Magazine," for October, 1874. He says that in the "Geological Magazine," vol. iii., 1871, p. 247, he gave a short account of the composition and structure of a Phonolite which forms the mass of the "Wolf Rock," lying between the Land's End and the Scilly Islands. The account there given has been noticed by Prof. Zirkel, in a work recently published, in which he refers to his (Mr. A.'s) description of some of the crystals stated to be nepheline, and suggests that they may be nosean. The passage to which he refers is as follows: "The grey dust filling some of the crystals is frequently collected together so as to form a dark or even black mass in the centre, the edges of which are sharply defined, and correspond exactly with those of the crystal. Hexagonal crystals, for example, exhibit a border filled with a fine grey dust, and a central portion occupied by a well-defined black hexagon, or there is sometimes a black band running parallel with, and at some distance from, the sides." To this Mr. Allport now adds, that some of the crystals and irregular grains are traversed by a number of very fine straight lines of a bluish

black colour, and that with a high magnifying power these lines are resolved into rows of extremely minute dark granules similar to those forming the dust. This remarkable structure, combined with that previously given, is so thoroughly characteristic of nosean that there can be no doubt of its presence in the rock; the mineralogical composition of which is thus found to be in complete accordance with that of the large series examined by Zirkel.

The late Eruption of Mount Vesuvius.—One of the most graphic and exciting sketches which we have seen on this subject is that of Mr. J. M. Black, in the "Proceedings of the Geologists' Association," vol. iii. No. 6. He was on the spot throughout the entire outbreak, and the effect produced on him he describes in such a marvellously forcible style, that we venture to say that few who will read his paper will not be equally impressed by his description of those wonderful phenomena.

The Record of Geological Literature.—We are very glad to see that it is intended to issue a yearly volume, which shall consist of a record of Works on Geology, Mineralogy, and Palæontology, British and Foreign. The first volume will be printed by the middle of 1875, and will contain short abstracts or notices of papers, books, maps, &c., published during the year 1874. It is estimated that this volume will contain from 200 to 300 pages, and that its price will be 10*s.* 6*d.* The gentlemen named below have volunteered to assist in the work, which has already been begun. Those marked * have taken charge of various sections (as Sub-editors), and the last has undertaken the post of general editor. Rev. T. G. Bonney, F.G.S., * W. Carruthers, F.R.S., F.G.S. (British Museum); C. E. De Rance, F.G.S. (Geological Survey); * R. Etheridge, junior, F.G.S. (Geological Survey of Scotland); D. Forbes, F.R.S., F.G.S.; Dr. C. Le N. Foster, F.G.S.; Prof. Geikie, F.R.S., F.G.S. (Director of the Geological Survey of Scotland); * Prof. A. H. Green, M.A., F.G.S.; Prof. T. R. Jones, F.R.S., F.G.S.; A. J. Jukes-Browne, B.A., F.G.S. (Geological Survey); * G. A. Lebour, F.G.S.; * L. C. Miall (Leeds Museum); E. T. Newton, F.G.S. (Jermyn Street Museum); * Dr. H. A. Nicholson, F.G.S.; * F. W. Rudler, F.G.S. (Jermyn Street Museum); E. B. Tawney, F.G.S. (Bristol Museum); * W. Topley, F.G.S. (Geological Survey); Henry Woodward, F.R.S., F.G.S. (British Museum); H. B. Woodward, F.G.S. (Geological Survey); W. Whitaker, B.A., F.G.S. (Geological Survey). The work will be greatly helped if Provincial Societies and Field Clubs will forward copies of their publications to the editor.

It is hoped, from the low price, that the number of subscribers (amounting to 140 before the issue of this circular), will be enough to cover the expenses of printing; but should this not be the case, the following gentlemen have kindly consented to act as guarantors:—Dr. Bigsby, F.R.S., F.G.S.; E. W. Binney, Esq., F.R.S., F.G.S.; Rev. T. G. Bonney, F.G.S.; Dr. Bowerbank, F.R.S., F.G.S.; J. Brigg, Esq., F.G.S., and Friend; C. Darwin, Esq., F.R.S., F.G.S.; T. Davidson, Esq., F.R.S., F.G.S.; J. Eccles, Esq., F.G.S.; Sir P. de M. G. Egerton, Bart., F.R.S., F.G.S.; The Earl of Enniskillen, F.R.S., F.G.S.; J. Evans, Esq., F.R.S. (*Pres. G. S.*); J. Fawssett, Esq.; D. Forbes, Esq., F.R.S. (*Sec. G. S.*); R. A. C. Godwin-Austen, Esq., F.R.S., V.P.G.S.; Capt. Marshall Hall, F.G.S.; J. Gwynn Jeffreys,

Esq., F.R.S. (*Treas. G. S.*); Sir J. Lubbock, Bart., F.R.S., F.G.S.; Sir C. Lyell, Bart., F.R.S., V.P.G.S.; G. Maw, Esq., F.G.S.; J. C. Moore, Esq., F.R.S., F.G.S.; J. A. Phillips, Esq., F.G.S.; J. Prestwich, Esq., F.R.S., V.P.G.S.; F. G. H. Price, Esq., F.G.S.; G. P. Scrope, Esq., F.R.S., F.G.S.; Sir W. C. Trevelyan, Bart., F.G.S.; H. Willett, Esq., F.G.S.; S. V. Wood, Esq., F.G.S. Names of intending subscribers, and of societies and institutions that will purchase the "Record" for 1874, will be gladly received by the editor, W. Whitaker, Geological Survey Office, Jermyn Street, London, S.W.

Gyrogonites in the London Clay.—Professor Rupert Jones, F.R.S., has written a letter on this subject to the Editor of the "Geological Magazine" [for October, 1874]. He says: "Believing that *Gyrogonites* (fossil seed-vessels of *Chara*) have not been hitherto noticed in the London clay, I beg to mention that Mr. Joseph Wright, F.G.S., of Belfast, has lately favoured me with some specimens found in the London clay of Copenhagen Fields, Islington, by Mr. John Purdue, when the Great Northern Railway cuttings were being made. These *Gyrogonites*, obtained by washing the clay, were associated with thousands of Foraminifera and many Entomostraca (see "Geologist," vol. vii. p. 85; Monogr. Tert. Entom., Pal. Soc., p. viii). They are referable to two species: one is dark brown, ovoidal, and like *Chara helicteres* (Brongniart), as figured in the Memoirs Geol. Surv. Gt. Britain, Isle of Wight, etc., 1856, pl. 7, figs. 3, 4, but relatively longer; the other is light brown, spherical, and like *Chara Lyellii*, ibid. fig. 7, but rather more globular. There are five or six specimens of each species. From the same source, and by the kindness also of Mr. Wright, I have *Cythere plicata* (Münster), to add to the known fauna of the London clay."

MEDICAL SCIENCE.

Wooden Hospitals and their Advantages.—An interesting paper on this subject has been written by Mr. John Gay. It appears in a recent number of the "Proceedings of the Medical Society of Victoria, N.S.W." The conclusions arrived at are as follow: 1. That, instead of requiring constant purifying and disinfecting as other hospitals do, they purify and disinfect themselves. 2. That peroxide of hydrogen, the disinfecting agent they generate, contains oxygen—Nature's disinfectant—in a highly condensed and active form, which, moreover, is intensified in the presence of either blood or pus—a property which renders it pre-eminently adapted for hospital disinfection; for it is beyond doubt that pus-cells, in combination with other organic matter, are largely concerned in the causation of those septic diseases which are so destructive to life in ordinary hospitals. 3. That, in consequence of the above-named conditions, the inmates of wooden hospitals enjoy almost, if not perfect, immunity from hospital gangrene, erysipelas, and puerperal fever.

The Rate of Growth in Man.—"La Revue Scientifique," in a recently published notice of the life and writings of A. Quetelet, gives the following: "The most rapid growth takes place immediately after birth; the infant in the space of a year grows about two decimètres. The increase in size

diminishes gradually as its age increases, up towards the age of four or five years; when about three it attains half the size which it is to become when full-grown. When from four to five years of age, the increase in size is very regular each year up to sixteen years, that is to say up to the age of puberty: this annual increase is nearly fifty-six millimètres. After the age of puberty the size continues to increase, but feebly; when from sixteen to seventeen years old the individual increases four centimètres (·60 inch). In the two years following it increases only one inch. The total increase in size of man does not appear to be entirely terminated when he is twenty-five years old. The mean size is a little larger in cities than in the country."

Have Animals the Power of changing their Colour according to Circumstances?—It would seem, from some recent researches of M. Pouchet, that they have this power. This was very well shown in some experiments he made on the *Palæmon Serratus*. The following is M. Pouchet's description: "Animals from three to four centimètres long are the best to experiment upon, placed in porcelain vessels with black or white bottoms. The crabs that fishermen bring ashore have a rose or a dark lily colour; if they are put into vessels with black or white bottoms, in twenty-four hours they will assume a colour wholly unlike each other. Those in the white dish are yellowish, almost colourless, as if they had just shed their skin, and those in the dark coloured dish are of a brown red colour. When changed, the pale one into the dark coloured dish, and *vice versâ*, they change colour in a corresponding manner. The change of a pale one to a dark colour was more rapid than the reverse. Under favourable conditions we can create a yellow, red, and blue Palæmon. If a foot is removed when any one of these colours is present, and put into a solution of sugar, the three colours appear successively before the eye. The microscope reveals the sequel to this. If the pigment cells are pressed together like balls, then they are too minute to mirror themselves upon the retina. As soon as the animal is placed upon a dark ground the colouring cells are distended and send out little branches on all sides; then they become perceptible to the eye. The animal becomes red rose coloured when nothing weakens the lively colour of the pigment cells. As the branches of the latter distend under the hypodermis they receive a cobalt colour, and the carmine of the pigment cells becomes thereby browned, and thus the Palæmon takes on a colour corresponding to the foundation. If the colouring cells contract again, the blue remains six or seven hours in the hypodermis, and then gradually disappears. With the Palæmon, as with fish, the change of colour is the result of visual impression."

Norwegian Tar in the Treatment of Wounds.—Tar, or tar water, is not a very novel means of treating wounds with. Still, M. Sarazin thinks it is, and he has presented the French Academy with a memoir on the subject. In this [Nov. 16, 1874] he states that he has treated several amputations [a list of which he gives] with Norwegian tar as an exclusive dressing, and all with the best results. He gives the exact mode of dealing with the wounds, according as they are upon the limbs or chest, but for this we must refer our readers to the memoir itself.

A new Compound in Urine has been discovered by Herr F. Baumstark. He has a paper in a recent number of "Liebig's Annalen," in which he says

that the substance in question, $C_3H_8N_2O$, has a strong resemblance to hippuric acid. It forms white columns of several millimètres in length. Freely soluble in boiling water; sparingly in cold water and spirits of wine; insoluble in absolute alcohol and ether. If heated to 250°, the crystals experience no change. If more strongly heated they decrepitate, evolve dense white vapours of peculiar odour, fuse, and finally burn with the odour of horn. It is neutral to test paper, does not combine with bases, but forms with acids salts which do not readily crystallise and deliquesce on exposure to the air.

Recent Researches on the Gastric Juice.—The "Chemical News" of Nov. 13th, 1874, says that Herr R. Maly finds that the pure gastric juice in dogs contains no lactic acid. The decomposition of chlorides by lactic acid cannot, therefore, be the source of the hydrochloric acid in the stomach. Lactic acid seems to play no part in the chemistry of the normal formation of acids. The source of the free hydrochloric acid in the stomach is a process of dissociation of the chlorides without the action of an acid.

What is Jaborandi?—We learn from the "Chicago Medical Examiner" of Nov., 1873, that this is a South American product; the leaves and small twigs are the parts of the plant used. The leaves have an odour and a bitter taste, but do not appear to have any alkaloids. Sixty to ninety grains of the leaves and twigs may be infused in a cup of water. "When taken, a drenching perspiration, or more properly, sweating, lasting four or five hours, necessitating several changes of clothes, will follow. At the same time an abundant salivary and bronchial secretion supervenes, which may even exceed two pints in quantity."

Muscular Contraction in apparent Death.—Dr. Labordette, in a communication on the contraction of the masseter as a sign of life, says that the laryngeal speculum, after having triumphed over the contraction of the masseter, is of service in recalling life; the contraction ceases on its application. On every occasion in which he was able to make the trial, it was found that, on the restoration to life, the jaw closed as soon as the instrument was withdrawn. If, on the contrary, the introduction is maintained, the elastic force, which Voisin says is due to trismus, becomes neutralised, and the obstacle to the introduction of air being thus overcome, the patient inspires and lives. If the speculum be introduced into the mouth of a cadaver, the remarkable fact becomes manifest, that, though the instrument is inserted very deeply, it does not become fixed. It may be withdrawn, and the mouth will remain open, corresponding with the absence of contraction in the masseters. In this way the double advantage is obtained of having a proof of death if the mouth remains open, and a means of recalling the life of the patient if the mouth closes. Any one can introduce the speculum, and thus assure himself whether death has really taken place.—"Gaz. Méd. de Bordeaux," and "New York Medical Journal," Nov., 1874.

Antiquities at the Obstetrical Society.—The last meeting of the Obstetrical Society, which was held on Wednesday, Dec. 2nd, was rendered specially attractive by the exhibition of the following curiosities:—A cast of an antique group, found at Cyprus not long since, representing the circumstances of labour, at a period, perhaps, B.C. 300, by Mr. Bibby, of Green-street; an engraved portrait, dated 1658, of Paul Chamberlin, M.D., inventor of the midwifery forceps, presented by Mr. Taylor, of Birmingham; and, by the courtesy of the President of the Medico-Chirurgical Society, Chamberlin's

original instruments. At the same time, Mr. Donald Napier lent for the occasion two rare books from his valuable collection—one an illustrated Bible, date 1587, which contains a representation of the lying-in chamber, and the other "Ye Happy Delivery of Women," by Guillemeau, 1612, black letter English.

METALLURGY, MINERALOGY, AND MINING.

Prizes offered in Connection with Steel.—We learn from Mr. D. Forbes's report on the Progress of the Iron and Steel Industries [1874], that the French Société d'Encouragement has announced a prize of 6,000 fr. (240*l.*), to be awarded in 1878, for "A theory of Steel, based on reliable experiments, and capable of being applied directly to the improvement in its manufacture;" also another prize of 3,000 fr. (120*l.*), to be awarded in 1876, for an industrial process for the manufacture of cast steel rails from common iron ores containing, like those from the carboniferous and oolitic formations, from 0·5 to 1·5 per cent. of phosphoric acid. In Germany, also, attention is being directed to the same subject, and Dr. Dubois Reymond, one of the Secretaries of the Academy of Science of Berlin, has announced that a prize of a hundred ducats (about 40*l.*) will be awarded in July, 1876, for the best memoir in which the question is experimentally answered as to whether the changes which take place in the tempering of steel are due to physical or chemical causes, or to a combination of both. Comparative analyses specially directed to the amounts of carbon in the steel, and its condition as free or combined carbon, are required, as well as observations relative to the physical characters of the metal. The memoirs may be written in German, French, Latin, or English, and must be sent in to the Academy, accompanied by a sealed note, with motto, before the 1st March, 1876.

Wood Tin in Georgia.—Mr. William P. Blake, in a communication to one of the editors of "Silliman's American Journal" [Nov. 1874], says that "in 1860, while examining a series of specimens of the residual black sand from the sluices used in collecting gold in North Carolina and Georgia, I found several minute grains of wood tin in the sand from the Nacoochee Valley, White County, Georgia. Although it occurs sparingly, the fact that it exists is worthy of record, as it may possibly be traced to larger deposits. I have examined sand from a great number of other localities, southwestward from Rutherfordton in North Carolina, without finding any traces of tin. The usual minerals of the 'black sand' about Dahlonega, Georgia, are specular iron, magnetite, ilmenite, rutile, cyanite, and garnet. At the Walton Branch, in North Carolina, corundum, zircon, and monazite are abundant, with the ordinary mixtures of iron minerals, and xenotime occurs in minute crystals, but no tin ore was found."

Permanent Ice in a Mine in the Rocky Mountains.—Mr. R. Weiser, of Georgetown, Colorado, states that geologists have been not a little perplexed with the frozen rocks found in some of our silver mines in Clear Creek Co., Colorado. There is a silver mine high up on McClellan Mountain, called the "Stevens Mine." The altitude of this mine is 12,500 feet. At the depth of from 60 to 200 feet the crevice matter, consisting of silica, calcite, and ore, together with the surrounding wall-rocks, is found to be in a solid

frozen mass. McClellan Mountain is one of the highest eastern spurs of the snowy range; it has the form of a horse-shoe, with a bold escarpment of feldspathic rock near 2,000 feet high, which in some places is nearly perpendicular. The Stevens Mine is situated in the southwestern bed of the great horse-shoe; it opens from the northwestern. A tunnel is driven into the mountain on the lode, where the rock is almost perpendicular. Nothing unusual occurred until a distance of some 80 or 90 feet was made; and then the frozen territory was reached, and it has continued for over two hundred feet. There are no indications of a thaw summer or winter; the whole frozen territory is surrounded by hard massive rock, and the lode itself is as hard and solid as the rock. The miners being unable to excavate the frozen material by pick or drill to get out the ore (for it is a rich lode, running argentiferous galena from 500 to 1,200 ounces to the ton), found the only way was to kindle a large wood fire at night against the back end of the tunnel and thus thaw the frozen material, and in the morning take out the disintegrated ore. This has been the mode of mining for more than two years. The tunnel is over two hundred feet deep, and there is no diminution of the frost; it seems to be rather increasing.

The immense Extent of American Oil Districts.—According to a recent statement in the "Scientific American," it seems that a late report on the Great Butler Oil District, covering the entire production of the country south and west of Pittsburgh, gives at present 596 producing wells and 81 wells now drilling. There are 1,076 engineers employed. The working capital invested is $1,859,000. The daily production of oil in this district is 15,548 barrels, which indicates a large decrease within the past month.

Mineralogical Communications, by Herr G. vom Rath.—These communications consist, according to the "Chemical News," of a contribution to our knowledge of the crystallisation and twin formations of tridymite; description of a remarkable crystal of calcareous spar from Lake Superior, *apropos* of which the author points out that a monograph of the modifications of calcareous spar would be a boon to mineralogists; a peculiar specimen of rutil and iron-glance grown together; remarkable crystals of artificial metallic copper; the discovery of hypersthene in a trachytic rock, *Rocher du Capucin*, near the baths of Mont Dore in Auvergne; and foresight, a new mineral of the zeolite family, from the granite veins of Elba. Foresight consists of—

Silica	49·96
Alumina	27·40
Lime	5·47
Magnesia	0·40
Potash	0·77
Soda	1·38
Water	15·07
	100·45

It is most nearly connected with desmin.

Lectures on Crystallography at the Chemical Society.—We may state that a considerable number of F.C.S. and others have joined the lectures by Professor Maskelyne, at Burlington House.

MICROSCOPY.

The Vascular System in Oikopleura.—Mr. J. Sanders, F.R.M.S., read a most valuable paper before a late meeting of the Royal Microscopical Society, on the anatomy of this genus. The paper, with two illustrations, will be found in the "Monthly Microscopical Journal" for Nov. 1874. With regard to the vascular system the author says: "The only part of the vascular system that is visible is the heart. The blood being colourless and totally devoid of corpuscles, unless some extraneous matter, such as zoosperms, becomes mixed with it, the vessels which convey it are invisible. The heart is situated between the right lobe of the stomach and the second part of the intestine. It is composed of several longitudinal fibres which are attached anteriorly along a transverse fibre, which, passing immediately in front of the right lobe of the stomach, is fixed to the parietes of the body. Posteriorly they join together to form a single fibre, which, passing behind this lobe, is in like manner attached to the parietes at that point. When the generative gland increases in size it pushes between the right lobe of the stomach and the first part of the intestine, giving the appearance as if the posterior end of the heart were fastened to its enveloping membrane. I am rather uncertain whether these fibres are united together by a membrane, but appearances are more in favour of the idea that it is not present in this species; at all events, the wall next the stomach is deficient, neither is there a cell present at either end; Mr. Ray Lankester's opinion, therefore, that the heart is a mere churning organ is so far confirmed."

The Slit in Focus of an Object-glass.—In the "Monthly Microscopical Journal" for Nov. Mr. Wenham, P.R.M.S., makes the following remarks. He says finally: "A few words concerning the slit in focus of object-glass, for cutting off all these disputed or false rays. It is difficult to annihilate this by theory. Having given the death-blow to Mr. Tolles's extra apertures, it may be treated with but little notice, but cannot be got rid of as a thing of no account or a mere sensational affair." Col. Woodward says: "This method might be used without giving rise to material inaccuracy when the objective is adjusted for uncovered objects; but when it is closed to the point of maximum aperture its spherical aberration is of course no longer corrected for uncovered objects." In measuring varying angles of aperture by the usual method, we take them at all points of the adjusting collar, and do not place in front a thickness of glass suitable for that correction, because with a parallel plate of glass there is no perceptible difference. The angle at the crossing point of the rays is the same whether it is there or not. I stipulate that the edges of the stop shall be in the crossing point. If anyone thinks proper to introduce an intervening plate of glass, serving no purpose, he must focus through it, so as still to get the stop in the focal plane. Further, if the collar is set for an object immersed balsam, for the purpose of testing its reduced aperture therein by the means I have described, the slit must be set in focus, whether air, water, or balsam is the intermedium. In Mr. Tolles's $\frac{1}{6}$th the immersed aperture was found to be the *same* with all three, simply because they are parallel plates.

How to Mount Diatoms Quickly but Roughly.—Although most micro-

scopists would only adopt the very best method of mounting, yet there are a few who would like to know how a preparation of diatoms may be quickly, if roughly mounted. Dr. A. M. Edwards gives the following method in the "Monthly Microscopical Journal" [No. LXXI.]: "If the microscopist," he says, "wishes to mount a few slides of recent diatoms, just to show what diatoms are, nothing is easier. It is only necessary to boil a small mass of them in strong nitric acid in a test-tube over a spirit lamp, and, when the acid has ceased to emit red or yellowish fumes, wash them thoroughly with clean water, allowing them to settle completely. Then a little of the clean sediment, consisting almost entirely of the shells of the diatoms, is taken up by means of a 'dip-tube,' and placed upon the central portion of a glass slide. Here it is dried, and the slide warmed over a lamp; then a drop of Canada balsam is permitted to fall upon the diatoms. As soon as all bubbles have cleared off from the balsam, a warm cover of thin glass is carefully laid upon it and permitted to settle into place. When cool, it is ready for examination by means of the microscope, any balsam which has exuded around the cover being washed off with alcohol. In this way rough and tolerably clean specimens may be obtained."

Microscopical Papers of the Past Quarter.—The following is a list of the various papers read before the Royal Microscopical Society of London, and published in the "Monthly Microscopical Journal" for Oct., Nov., and Dec., 1874:—

The Hairs of Caterpillars. By T. W. Wonfor (Hon. Sec. Brighton and Sussex Natural History Society).—On Bog Mosses. By R. Braithwaite, M.D., F.L.S.—The Pebrine Corpuscles in the Silkworm, and what they are analogous to.—On the Microscopical Characters of the Sputum in Phthisis. By John Denis Macdonald, M.D., F.R.S., Staff-Surgeon R.N., Assistant Professor of Naval Hygiene, Netley Medical School.—Blue and Violet Stainings for Vegetable Tissues. By Christopher Johnston, M.D., Baltimore, U.S.A.—A Physicist on Evolution: being a part of Professor Tyndall's Address to the British Association at Belfast.—Supplementary Remarks on Appendicularia. By Alfred Sanders, M.R.C.S.—New Diatoms. By F. Kitton, Norwich.—Final Remarks on Immersed Apertures. By F. H. Wenham, V.P.R.M.S.—The Filaria Immitis. Amended Anatomical Details. By F. H. Welch, F.R.C.S., Assistant to Professor of Pathology, Army Medical School, Netley.—How to Prepare Specimens of Diatomaceæ for Examination and Study by means of the Microscope. By A. Mead Edwards, M.D., Newark, New Jersey, U.S.—Continued Researches into the Life History of the Monads. By W. H. Dallinger, F.R.M.S., and J. Drysdale, M.D., F.R.M.S.—On some Microscopic Leaf Fungi from the Himalayas. By Joseph Fleming, M.D., F.R.C.S., Surgeon Army Medical Department.—The Sphæraphides in British Urticaceæ and in Leonurus. By Professor George Gulliver, F.R.S.—The Encystment of Bucephalus Haimeanus. By M. Alf. Giard.

PHYSICS.

A Comparison of the Different Methods of Aerial Navigation.—This is made in a recent paper (published in the "Comptes Rendus" for Nov. 9, 1874), by M. Duroy de Bruignac. He divides all methods into two systems, the *Aërostat* and the *Aëroplane*; and he also alludes to a mixed system, the *Mixed Aëroplane*. The paper is partly mathematical, and therefore unsuited to most of our readers, but we refer to it as some of them may be interested in knowing of it. The subject appears to be fairly worked out.

A Patent Recording Thermometer has been lately devised by Messrs. Negretti and Zambra, which bids fair to supersede all former plans of instrument. It is said of it by the makers that it contains only mercury, without any admixture of alcohol or other fluid. It has no indices or springs, and its indications are by the column of mercury. It can be carried in any position, and cannot possibly be put out of order, except by actual breakage of the instrument.

The Earliest Scientific Notice of Mirage.—In a paper by Professor Everett, published in the "Proceedings of the Belfast Natural History Society" [1874], he says that the earliest explanation of mirage on record is that of Monge [Ann. de Chim. xxix., 207], one of the savans who accompanied Bonaparte in his expedition to Egypt. The following is the passage in the Annals, which purports to be an abstract of a memoir read at a meeting of the Institute, held at Cairo: "At sea it often happens that a ship seen from afar appears to be floating in the sky, and not to be supported by the water. An analogous effect was witnessed by all the French during the march of the army across the desert.. The villages seen in the distance appeared to be built upon an island in the midst of a lake. As the observer approached them, the boundary of the apparent water retreated, and on nearing the village it disappeared, to recommence for the next village. Citizen Monge attributes this effect to the diminution of density of the inferior layer of the atmosphere. This diminution in the desert is produced by the augmentation of temperature, which is the result of the heat communicated by the sun to the sands with which this layer is in immediate contact. . . . In this state of things the rays of light which come from the lower parts of the sky, having arrived at the surface which separates the less denser layer from those which are above, do not penetrate this layer: they are reflected, and thus form in the eye of the observer an image of the sky. He thus sees what looks like a portion of the sky beneath the horizon, and it is this which he takes for water."

The Electric System of Gas Lighting at the National Assembly at Versailles.—We do not know whether the method adopted is the same as that which is employed in lighting the three thousand seven hundred jets at the Albert Hall in South Kensington, but according to M. Lissajous [in the "Bull. de la Soc. d'Encouragement pour l'Industrie Nationale," Nov. 10, 1874], it is as follows: A Ruhmkorff coil of medium size, with an automatic mercurial interruptor, is set in action by a Leclanché battery of four elements, the zincs having a surface of 4 square decimètres. These are only equiva-

lent to three Bunsen elements of a middle size, but their duration is much greater. Under the influence of this battery the coil gives sparks of 15 centimètres. To transmit the electricity to the different lustres, a special wire is employed for each, but the return current passes through one common wire.

The Fluorescence of Bodies in Castor Oil.—Mr. C. Horner has shown that many substances which have no fluorescent properties when dissolved in alkaline solutions, or in alum or alcohol, fluoresce very brilliantly when they are dissolved in castor oil.

A New Helio-photometer has been described by M. F. Craveri, in the "Moniteur Scientifique," October 1874. It thus appears in the "Chemical News" for November 13: A box of hard wood, 280 mm. long, 145 mm. wide, and 200 high, forms a parallelopiped placed upon a pedestal in an open situation, where nothing impedes the direct action of the sun. The upper surface of the apparatus cannot preserve, during the twelve months of the year, a horizontal position, because when the sun sinks below the equator in winter its rays would fall too obliquely. It is therefore necessary at that season to follow approximately the movement of the sun. This result is obtained by gradually inclining the instrument towards the south from September to December, and gradually diminishing the inclination again till March, when it is replaced in a horizontal position. One of the principal sides of the parallelogram represents the door, fixed on hinges, and giving access to all the interior. At the side opposite the door is fixed a clock, the dial of which is seen through a circular aperture in the side. To this clock is adapted a toothed wheel, moved by the drum containing the spring. This wheel only performs one revolution in twenty-four hours. To its axle is fixed by a movable screw a large drum of brass, the circumference of which is 520 mm., and the breadth 16 mm. Upon the surface of this drum is fixed a slip of paper, as is done with the Morse telegraphs. A few seconds are sufficient for fixing or for removing this band. A slit in the box is so arranged that the sun's rays, shining through it, fall upon the band, even when the luminary is very near the visible horizon. The bands are prepared with chloride of silver by being steeped first in a solution of common salt, and then, shortly before being used, in solution of nitrate of silver.

Magnetic Condensation in Soft Iron.—A paper is published in the "Comptes Rendus," October 19, on this subject. The magnetic condensation, first observed and studied by M. Jamin in steel, occurs also in soft iron with a very remarkable intensity and persistence. A horse-shoe electro-magnet is formed by a cylinder of iron, 4 centimètres in diameter, each limb of which is surrounded with a coil of wire of 2 mm. in diameter, and 150 mm. in length. The armature is a blade of soft iron 2 cm. in thickness, and 4 in width. When the double coil is traversed by the current of a single Bunsen element, feebly charged, the keeper is able to support about 150 kilos. On interrupting the current the keeper remains strongly adhesive, a fact already often observed. It can support as much as 50 kilos. without detaching itself, but after this rupture every trace of magnetism disappears, and the electro-magnet is not even able to support the keeper. We might suppose that cohesion might be partly concerned in the

adherence of the armature after the cessation of the current; but this is not the case, since no cohesion is manifested even under a greater pressure than that caused by magnetisation. Moreover, a magnetic needle placed in the vicinity of one of the polar surfaces shows a marked deviation, which disappears as soon as the keeper has been torn away. But what is particularly worthy of notice is the persistence of this magnetic condensation. An electro-magnet has been left for twenty days, and at the end of this time the keeper still supported 50 kilos. without becoming detached.

ZOOLOGY AND COMPARATIVE ANATOMY.

Philosophical Experiments on the Auditory Apparatus of the Mosquito.—Professor A. M. Mayer has published in the "American Naturalist" [Oct. 1874] the results of a great number of most philosophically conducted experiments on this insect, and, as his paper is of some length, we must refer our readers to it as being a most valuable scientific record. He states—after recording some of his experiments, conducted with tuning-forks—that he thinks that it is to be regretted that König did not adhere to the form of fork, with *inclined prongs*, as formerly made by Marloye; for with such forks one can always reproduce the same initial intensity of vibration by separating the prongs by means of the same cylindrical rod which is drawn between them. Experiments revealed a fibril tuned to such perfect unison with Ut_3 that it vibrated through eighteen divisions of the micrometer, or ·15mm., while its amplitude of vibration was only three divisions when Ut_4 was sounded. Other fibrils responded to other notes, so that he infers from his experiments on about a dozen mosquitoes, that their fibrils are tuned to sounds extending through the middle and next higher octave of the piano.

The Development of the Ova and the Testicles in the Hydractiniæ.—M. Van Beneden has recently published an exceedingly valuable paper on the above. The following are the conclusions to which he is led by his researches: In the Hydractiniæ, 1. The eggs are developed exclusively from the epithelial cellules of the endoderm. They remain, up to the time of their maturity, surrounded by the elements of the endoderm. 2. The testicles and spermatozoa are developed from the ectoderm. This organ results from the progressive transformation of a primitive cellular fold formed by invagination. 3. There exists in the female sporosacs a rudiment of the testicular organ; in the male sporosacs a rudiment of an ovary. The sporosacs are then morphologically hermaphrodites. . . . . Fecundation consists in the union of an egg, a product of the endoderm, with a certain number of spermatozoa, products of the ectoderm. This act has no other end than to unite chemical elements of opposite polarity, which, after having been united an instant in the egg, separate again; for in most animals, those in which the division of the vitellus into two occurs, the elements from which the ectoderm are formed are already separated from those which are to form the internal layer of the embryo.

The Development of the Tracheæ in Flies.—An excellent memoir on this subject is that of Herr Weismann, which has been recently translated

in the "American Naturalist" [Oct. 1874]. It seems that the tracheary system is completed last of all. The first positive condition is assumed on the fifteenth day, and by the seventeenth it is generally entirely formed. The trunks arise for the most part by means of the masses of nuclei out of the originally solid series of cells, the terminal branches of the organ out of a single cell; the hollow space between them will form the cavity of the trachea, while they branch out by growing outwards. Yet these cells may for the most part be traced back to the masses of nuclei, but soon, and especially within the inner of the bundles of primitive muscles of the thorax, *they arise from an organisation of the histological formative elements at hand, i.e. the muscular nuclei.* This remarkable fact does not take place without a reaction in the muscular fasciculæ themselves; their sarcolemma disappears, and they deteriorate into fascicles of tracheæ, wanting the spiral thread. All the organs which have tracheæ intimately connected with them have the same developed in the last three days. The tracheæ grow out in the nervous centres, in the bulb of the eyes, and the alimentary canal in its entire course is surrounded by a network of them. They are sent to the rectal papillæ in great abundance and with a peculiar development. The dorsal vessel, also, and the entire muscular system, receives tracheæ, and likewise the genital cavities with their outlets and accessory apparatus.

Gossamer Spiders; their Work.—Dr. G. Lincecum has read a paper of much interest before the Smithsonian Institute [1874]. From this we extract the following passage: "I once observed one of these spiders at work on the upper corner of an open, outside door-shutter. She was spinning gossamer, of which she was forming a balloon; and clinging to her thorax was a little cluster of minute young spiders. She finished up the body of the balloon; threw out the long bow lines, which were flapping and fluttering on the now gently increasing breeze, several minutes before she got all ready for the ascension. She seemed to be fixing the bottom and widening her hammock-shaped balloon. And now the breeze being suitable, she moved to the cable in the stern, severed it, and her craft bounded upwards, and, soaring away northwards, was soon beyond the scope of my observation. I was standing near when she was preparing to cast loose the cable, and had thought I would arrest its flight, but it bounded away with such a sudden hop that I missed and it was gone."

The Generative Apparatus in the Gasteropoda.—In the last published number of the "Proceedings of the Academy of Natural Science, Philadelphia," Dr. Chapman makes the following remarks on the generative apparatus of *Tebennophorus Carolinensis*: "Various have been the interpretations offered from time to time of the generative organs of the Gasteropoda. Thus Cuvier considered what is now regarded as an hermaphroditic organ to be the ovary. Later observers regarded this hermaphroditic organ as the testicle, and considered what is now supposed to be an albuminous gland the ovary, and which Cuvier regarded as part of the testicle. With reference to these views, I have recently dissected the Tebennophorus Carolinensis, a slug found often in our environs under trees, &c., and found both ova and spermatozoa in the organ regarded first as simply the ovary, later as the testicle. I take the opportunity of acknowledging the assistance afforded me in my dissection by Dr. Leidy's beautiful monograph on the Gasteropoda."

DEATH OF MR. HARDWICKE.

It is our painful duty to record the death of our publisher, Mr. Robert Hardwicke, which occurred on the morning of Monday, March 8, at the age of 52 years, after an illness which lasted but for ten short days. Thus was he cut off nearly in his prime, at a time too when his business relations were almost at their best. Of his friends it is not too much to say, that those who knew him longest knew him best, and have only to record their extreme sorrow for his loss. For assuredly there were none who were more thoroughly kind, genial, and considerate in all their dealings. Never before, in the course of our experience, have we met with one, with whom we have never within the period of ten long years had a single bitter word. All his dealings were kindly, none were severe. And though we feel that the fewest words are best when all are vain, we cannot help expressing our bitter sorrow at his death. For we have not the least hesitation in saying that we have lost a good, sincere, and earnest friend.

INSECTS AND FLOWERS.

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[PLATES CXIX and CXX.]

In his charming little book on "British Wild Flowers in Relation to Insects," which ought to be in the hands of everyone interested in the subject, Sir John Lubbock makes a few observations on the form of pollen-grains, in relation to the fertilisation of flowers; but there is but little information at present to be found in botanical works on this point. The anatomical structure of the pollen-grain has been the subject of abundant research; but the feature of chief importance in connection with the means of transport is the external form of the grain, to which but little attention has been directed, at least in this country. With the exception of a few stray notes scattered through botanical and microscopical journals, the only publications bearing on the subject, illustrated by drawings (without which they are comparatively useless), are in German:—Schacht, in Pringsheim's "Jahrbuch," vol. ii. for 1860;

Fritzsche, "Beiträge zur Kenntniss des Pollen," 1832; and Mohl, "Beiträge zur Anatomie und Physiologie der Gewächse," 1834; the first of these being the only one bearing at all a recent date. There is, besides, a magnificent series of unpublished drawings by Bauer in the British Museum.

The size and form of the pollen-grain is, within very narrow limits, uniform in the same species; and an adaptation may frequently be observed to the normal mode of fertilisation of the species. In the pollen-grains of which drawings will be found on Plate CXIX., the size varies from less than $\frac{1}{2000}$ of an inch in diameter, in the case of *Hoteia japonica* (fig. 38), to nearly $\frac{1}{200}$ in that of *Cobœa scandens* (fig. 54). In relation to their mode of pollination, flowers may be divided into two classes, the "anemophilous," in which the wind, and the "entomophilous," in which insects are the main agent. The former are almost without exception flowers without beauty of form, colour, or scent; to the latter belong all plants with conspicuous, brightly-coloured, or sweetly-scented flowers, and, as Darwin has pointed out, all with irregular corolla. Between these two classes of flowers there is a marked difference in the external form of their pollen-grains. In the former case the object is to enable them to be carried easily by the wind to reach the female flowers (for they are very commonly unisexual), or the pistil in some other flower. To effect this purpose the pollen is always very dry and dusty, the grains not very large, usually nearly or quite spherical, and never spiny nor marked with conspicuous furrows or protuberances. The following pollen-grains drawn on Pl. CXIX. illustrate the appearance presented in the case of anemophilous plants. Fig. 1 is the pollen-grain of the hazel, fig. 2 of the birch, and fig. 3 of the balsam poplar (*Populus balsamifera*), all nearly perfectly spherical and quite smooth, with but very slight angularities or protuberances. It is true the pollen of the hazel has been described* and even drawn as "triangular;" but I suspect this must have arisen from the fact of its having been mounted in glycerine for the microscopic slide. Immersion in any thick fluid has the effect of altering the shape of the grain, by exciting the incipient growth of the pollen-tubes. I have in my collection a slide of the pollen of *Polygala myrtifolia* mounted in glycerine, in which the tubes are as long as the longer diameter of the grain. The proper way of observing the form of the pollen in its condition when escaping from the anther—which is of course the state in which it is carried by the wind or by insects—is to dust it off on to a glass slide, and observe it at once dry and without any covering-glass. Examined in this way, I have found the pollen of these three plants scarcely to deviate perceptibly from the spherical

* "Nature," vol. ix. p. 440.

form when magnified 250 diam. Fig. 4 is *Luzula campestris*, nearly spherical, but with a depressed band of lighter colour, dividing the grain into three nearly equal sections. Figs. 5 and 6 represent the pollen of plants the mode of fertilisation of which is doubtful; the former is that of the dog's mercury, *Mercurialis perennis*, elliptical but quite smooth, and covered with very fine reticulations; the latter of the box, spherical, but with a number of slight protuberances irregularly dispersed over the surface of the grain. *Plantago lanceolata* is described by Müller* as having three distinct forms of flower, and he suggests that it may be a species in a transitional state from anemophilous to entomophilous. It is probable that the form of the pollen may also vary. Fig. 7 represents that observed by myself, nearly spherical or with badly defined angles, and traversed by a single equatorial ridge, with several darker spots where the pollen-tubes are emitted. I find the colour described in my notes as nearly white, but some of the more perfect grains with a deep orange surface, very smooth and shining. In figs. 8 and 9 we have the grains of two grasses, the common *Poa annua*, and the "quaking-grass," *Briza media*. The spherical form is here somewhat departed from; but they are exceedingly light and smooth. The microscope shows various bright spots, which have the appearance of depressions or holes. Fig. 10 is the oval perfectly unfurrowed grain of *Dactylis glomerata*.

In flowers which are fertilised by the agency of insects the form and size of the pollen-grains vary to a much greater extent, and we find several distinct contrivances for the purpose of facilitating their attachment to the legs or bodies of bees, flies, and other insects. The most important of these are three:—longitudinal furrows varying in number from three to eight or nine or even more; the clothing of the surface of the grains with spines or other prominent projections; and the connecting them together by means of viscid threads. By far the most common form of pollen-grain is ellipsoidal, with three or more longitudinal furrows. Grains of this shape are obviously more calculated to cling to the hairs that clothe the legs and bodies of insects than perfectly spherical ones; while on the other hand they would not be so readily carried by the wind. Illustrations of such grains with three furrows are afforded by fig. 11, *Ranunculus Ficaria*; fig. 12, *Aubrietia deltoidea*; fig. 13, *Viola sylvatica*; fig. 14, *Aucuba japonica*, in which the anthers appear to be filled with an oily fluid; fig. 15, *Lamium album* (yellow); fig. 16, *L. purpureum* (red); fig. 17, *Nepeta Glechoma* (white); fig. 18, *Platanus orientalis*; fig. 19, *Convallaria Polygonatum*; and fig. 20, *Bryonia dioica*.

* "Befruchtung der Blumen durch Insekten," p. 342.

The pretty genus *Polygala* is characterised by a very remarkable form of pollen-grain. They are somewhat barrel-shaped, bulging in the middle, and with a considerable number (in *P. myrtifolia*, fig. 21, from twenty to twenty-four) of regular longitudinal alternate ridges and furrows. They are very beautiful objects under the microscope. In the various species of *Primula* characterised by "dimorphic" flowers, the grains are small, shortly cylindrical rather than ellipsoidal, and with a varying number of furrows. There is also this remarkable peculiarity, that as far as my observation goes, the pollen-grains of the long-styled form are invariably smaller than those of the short-styled form; at least this is the case in the primrose, cowslip, and polyanthus.*

In figs. 22 and 23 we have the long and short-styled forms of the primrose, figs. 24 and 25 of the cowslip, and figs. 26 and 27 of the polyanthus (transverse view). The explanation of this difference which has been suggested by Darwin and Lubbock, is a very ingenious and probable one. The long-styled form of *Primula* would of course require longer pollen-tubes to penetrate the style in order to reach the ovules than the short-styled form. It is fertilised normally by the short-styled form, and this latter form is therefore provided with pollen-grains of a larger size. In *Primula japonica* (in which I am not aware whether the two forms occur) the form of the pollen-grain is very different (fig. 28)—a triangular plate with three deep furrows. Occasionally in anemophilous flowers we have spherical furrowed grains, as in *Dicentra speciosa* (fig. 29), where there are also some irregularly disposed protuberances; or *Plantago media* (fig. 30), which approximates somewhat to the irregular form of *P. lanceolata*. Sometimes also we have ellipsoidal grains without any apparent furrow, as in *Anthriscus sylvestris* (fig. 31), *Adoxa Moschatellina* (fig. 32), which is somewhat lenticular, *Narcissus poeticus* (fig. 33), and the very large grains of *Fritillaria imperialis* (fig. 34) and *F. Meleagris* (fig. 35). Others again are characterised by being furnished with protuberances scattered irregularly over the grains, as *Ribes aureum* and *R. fruticosum* (figs. 36 and 37), the protuberances apparently causing the grains to adhere together in masses. In the very minute pollen-grain of *Hoteia japonica* (fig. 38), there is one such protuberance on each side, which is the case also with *Saxifraga crassifolia* (fig. 39). The section of the genus

* I have Mr. Darwin's authority for saying that his statement to the contrary effect, which will be found in his paper on the species of *Primula* in the "Journal of the Linnean Society," vol. x. p. 393, is an error, which will be found corrected elsewhere in his writings, and in those of Hildebrand and Lubbock. It has however been copied into several of our text-books.

Viola, known as *Melanium*, has a very remarkable form of pollen-grain. They are of a (comparatively) enormous size, the lateral aspect presenting nearly a rectangular parallelogram, the transverse aspect a nearly regular pentagon or hexagon. Fig. 40 represents the two views of the garden pansy, fig. 41 the side view of *Viola lutea*, and fig. 42 the transverse view of *V. cornuta*, offering a remarkable contrast to the size and form of the grains in the section *Nominium* of the same genus (see fig. 13). There is no doubt that this variation is connected with a difference in the mode of fertilisation in the two sections—a view which is confirmed by the great difference in the form of the stigma.

The form of pollen-grain covered with a number of distinct sharp spines, is characteristic of certain natural families, especially Malvaceæ, some sections of Compositæ, and some Cucurbitaceæ. They are usually, but not always, spherical. Fig. 43 is the very large and beautiful grain of the hollyhock (*Althæa rosea*). The grain of the garden *Cineraria* (fig. 44), presents about twenty-four of these spines round any diameter. Fig. 45 is the spherical grain of the dandelion (*Taraxacum officinale*); fig. 46 the ellipsoidal furrowed one of the groundsel (*Senecio vulgaris*).

Pollen-grains fastened together by viscid threads, so as to enable them to be carried about with greater facility in masses, are of various sizes and forms. One very familiar variety occurs in the various species of *Rhododendron* and *Azalea*; another is afforded by the well-known triangular grains of the Onagrarieæ, as illustrated by the *Fuchsia* (fig. 47), and another by the "touch-me-not," or *Impatiens*. The same occurs in Caryophyllaceæ, as *Stellaria Holostea* (fig. 48), and *Lychnis diurna* (fig. 49), where the grains are also covered with a great number of tooth-like or wart-like projections. The smooth oval furrowless grains of *Salix nitens* (fig. 50) are connected together in the same way. A different mode of adhesion is exhibited by the pollen of *Canna indica* (fig. 51). The grains are first of all hexagonal, and firmly attached together by their sides; but after they become separated from one another appear almost perfectly spherical; they are furnished with a number of minute spines. A very similar appearance is presented by the pollen of *Alpinia* (fig. 52). In the cultivated "white Arum" *Richardia africana* (fig. 53), the grains are variable in size, oval, without furrows, and connected together in long strings and masses. The pollen-grain of *Cobæa scandens* (fig. 54), is one of the most magnificent objects under the microscope. Perfectly spherical in outline, and nearly $\frac{1}{200}$ of an inch in diameter, its surface is cut up into minute hexagonal facets, reminding one of the eyes of a fly.

A very interesting illustration of the relation between the

form of the pollen and the mode of pollination was brought out in a recent examination of perfect flowering specimens of the "Kerguelen's Land Cabbage" sent home from the *Challenger* expedition, who had used it largely as a vegetable while in those inhospitable regions. *Pringlea antiscorbutica* differs from the normal type of the order Cruciferæ, to which it belongs, in the entire absence of petals, the absence of honey-glands at the base of the flower, the long exserted style, and the stigma covered with long papillæ—all pointing, as suggested by Dr. Hooker, to the conclusion that the *Pringlea* is an anemophilous species in an order usually entomophilous. This inference is in harmony with the fact of the almost entire absence of winged insects in that country, which is constantly swept by the most furious winds. It is true that Mr. Moseley, the naturalist to the *Challenger* expedition, reports having found numbers of an apterous fly crawling over the foliage of the plant; but, singularly enough, he saw none on the inflorescence itself; whether they have any share in the fertilisation of the flower will remain for future explorers to discover. Having an opportunity of examining the pollen-grains under the microscope, I found them altogether in accordance with the hypothesis that the pollen is carried by the wind. While the usual form of the grains in Cruciferæ is ellipsoidal and three-furrowed, as illustrated in *Aubrietia* (fig. 12), or in the more nearly allied *Sisymbrium officinale* (fig. 55), those of *Pringlea* are, as exhibited in fig. 56, very minute and perfectly smooth and spherical.

Hermann Müller, who has devoted much attention to the reciprocal adaptations of flowers and insects to each others' needs, has described in his "Befruchtung der Blumen durch Insekten," and in greater detail in "Nature" (vol. viii. p. 433, *et seq.*), a remarkable kind of "dimorphism" exhibited by certain flowers. Our figs. 1 and 2 (Plate CXX.) are taken from the latter series of papers, and illustrate the phenomenon in the case of the common eye-bright, *Euphrasia officinalis*, so pretty an ornament to our hill-sides and heaths. If the specimens of this flower growing in different localities are observed, it will be found that those that inhabit more open sunny places have larger and more brightly-coloured flowers, while the flowers of those in more shady situations are smaller and paler—the relative sizes being represented by figs. 1 and 2 (both considerably magnified)—and that this difference in size is accompanied by other structural differences which favour cross-fertilisation in the one, self-fertilisation in the other case. If a flower of the larger form which has just opened (fig. 1 *a*) is examined, the stigma, *st*, already in a receptive condition, considerably overtops the anthers, *an*. Each of the two lower

anthers is provided with two long hairs, *h*, which, in this stage of the flower, project into the opening of the corolla, so that an insect thrusting its head into the flower necessarily strikes against them, and in so doing shakes the pollen out of all the anthers on to its proboscis, and then carries it to the next flower it enters. At a later stage the parts occupy the relative position shown in *b*; and by this time the stigma is brown and withered, so that self-fertilisation is impossible. In the flower of the smaller form, (fig. 2), the anthers have completely discharged their pollen before the flower has fully opened (in the state shown in *a*); and the stigma, *st*, instead of overtopping the anthers, is slightly below and almost in contact with them. When the flower is fully open (*b*, *c*) the stigma is already withered up, so that cross-fertilisation is almost impossible. Dr. Müller has observed three species of Diptera and four of Hymenoptera visiting the larger form of the *Euphrasia*, but never any on the inconspicuous ones. The same dimorphism is found, under similar conditions, in several other plants—Müller mentions especially *Lysimachia vulgaris* and *Rhinanthus Crista-galli*—accompanied by similar contrivances for ensuring different modes of fertilisation. In the latter case the two forms have been described as distinct varieties, *R. Crista-galli*, *a*, and *β* Linn., and even as distinct species, *R. major* and *minor* Ehrh. In this last plant the small-flowered form appears to be frequently visited by insects, and to be self-fertilised only when by any chance it is left unvisited.

One of the most remarkable contrivances for ensuring cross-fertilisation is exhibited by the birth-wort (*Aristolochia Clematitis*) a rare wild flower in our southern counties. Fig. 3 *a* represents a flower cut through lengthwise when just opened. The stigmas, *st*, are in a receptive condition; but the anthers, *an*, are still closed. A small insect, *in*, which has brought on its back a mass of pollen from an older flower, has passed through the tube of the calyx, *t*, and reached the globular cavity below; the retrorse hairs which clothe the tube of the calyx effectually preventing its exit when once imprisoned. During its imprisonment the insect is sure to deposit some of the pollen on the stigma, the lobes of which then curve up, as represented in *b*. This curving up of the stigmatic lobes enables the anthers to open and discharge their pollen, some of which must adhere to the bodies of the still imprisoned insect. The hairs in the calyx-tube now die away, so as to allow the insect to escape and carry the fresh load of pollen to other flowers. But the flower has now altogether altered its position.. As long as the stigma was still in a receptive condition, the pedicel was erect, and the calyx open

(as represented in *a*), inviting the visits of insects. But as soon as the pollination of the stigma has been effected, the pedicel bends sharply downwards just beneath the ovary, so as to bring the flower into a pendent position; and by the time the insects have escaped, laden with pollen, the standard-like lip, *l*, of the calyx bends over so as to close up the orifice (as seen in *b*), and prevent any further incursions. The relative position of the reproductive organs would seem to render self-fertilisation impossible in this flower; and as many as six or eight flies have been found imprisoned at one time in the globular cavity of the calyx.

The position of a bee when sucking the honey from a flower with a tubular corolla is well shown in fig. 4, copied from Sprengel's "Entdeckte Geheimniss der Natur," representing a flower of *Stachys sylvatica* so visited. It was in fact the very instance here depicted which led Sprengel to the discovery that in "dichogamous" flowers, where the reproductive organs are not mature simultaneously, these organs occupy successively nearly the same position in the flower at the period of maturity of each, so that the very same part of an insect's body which rubs the pollen out of the anthers of one flower comes into contact with the stigma of another flower. Well might Sprengel exclaim, when the general truth of this law first began to dawn upon him, "Who must not admire the perfection of the structure, both of this flower and of this bee! Who cannot perceive that the Creator has adapted each one for the other, and has so constructed them that each supplies the need of the other!" Readers of Darwin's work on the Fertilisation of Orchids will recollect that from the extraordinary length of spur of that remarkable orchid *Angræcum sesquipedale* he draws the conclusion that Madagascar, its native country, must be the home of moths with a proboscis capable of extension to a length of between ten and eleven inches, for which purpose only could a spur be provided of such enormous length. A very short time since, Dr. Fritz Müller vindicated the sagacity of our great naturalist by sending home from Brazil the proboscis of a moth * captured in the province Sta. Catharina, of precisely that length.

The mode in which bees obtain the honey from flowers has been a subject of much controversy among naturalists. Swammerdamm, two centuries ago, erroneously described the tongue as a hollow tube, perforated at the extremity. This error was detected by subsequent observers, who taught—also erroneously—that the tongue of bees is merely a licking and not a sucking organ. This is indeed the teaching of most modern

* Drawn in "Nature," vol. viii. p. 223.

entomologists, even of so accomplished an observer as Milne-Edwards, who says that "honey-bees obtain their food not by sucking, but, as it were, by lapping, nearly in the same manner as a cat does." The same view is held by Carl Vogt and Gerstaecker. Hermann Müller, however, considers that he has proved that bees and other Hymenoptera really do suck honey. Fig. 5 (borrowed from him) represents the oral apparatus of a hive- or humble-bee stretched out to its fullest extent. The most prominent portion of this apparatus is the long tongue or *ligula*, *li*, at the end of which is a little membranous lobe, *w*, which was erroneously taken by Swammerdamm for a perforation. The ligula is composed of a number of rings, each provided with a whorl of hairs, which can be erected or pressed closely to the ligula at will. This ligula can be partially drawn back into the tubular *mentum*, *mt*. On each side of the ligula, and inserted into the mentum, are the *labial palpi*, *pl*, the two first joints of which are flattened and very slender, with a central rib, forming a sheath to the tongue, enclosing it from below, whilst the two small joints at the tips serve as feelers. The maxillæ terminate in two flat lanceolate horny pieces, the *laminæ*, *la*, each with a central rib, which also form a sheath to the tongue, enclosing it from above. The *maxillary palpi*, *pm*, occur in the mouth of typical bees only as atrophied useless organs. When a bee is obtaining honey from a flower, it may be seen to execute in succession a number of distinct acts of suction, sometimes as many as eight or ten, each act being accompanied by a protrusion of the tip of the tongue, followed by a retraction of it and of the whole sucking-tube. The mechanism of these movements is thus described by Müller :—In order to reach the bottom of a deep nectary, the bee stretches out the whole of the movable parts of the sucking apparatus, as shown in fig. 5, except that the two first joints of the labial palpi sheathe the tongue from beneath, while the laminæ closely embrace the mentum and the basal part of the tongue from above. When the terminal hairy whorls of the tongue, protruded as far as possible, are wetted with honey, the bee withdraws the mentum, together with the tongue and the labial palpi, so far that the laminæ are no longer overtopped by the latter, and that the laminæ and the palpi together, closely embracing the tongue, form a sucking-tube, of which only the upper part of the tongue above the labial palpi is prominent. The bee then withdraws the hairy whorls of the tongue, wetted with honey, into this sucking-tube; and the suction of the honey into the œsophagus is accomplished by the enlargement of the interior abdominal hollows connected with the œsophagus—which is visible from the outside by the swelling of the abdomen—and the simulta-

neous action of the whorl of hairs on the tip of the tongue gradually progressing downwards towards its base. These various movements Müller was able to follow by intoxicating bees with chloroform, and then immersing the tip of the tongue into a solution of sugar. When the bee is flying on a honey-seeking expedition, it carries its sucking apparatus stretched forwards, so as to be able to put it directly into the opening of the nectary; its tongue being perfectly enclosed between the labial palpi and the maxillæ, and the delicate whorls of hairs thus protected from injury. Bees frequently require to obtain the fluid from the cellular tissue itself of the petals, as in the hyacinth and some species of orchis, or from nectaries too deep to be reached by the proboscis, as in the heath or clover; for this purpose they sometimes bite the flowers by their mandibles, but more often pierce it by the extremities of the maxillæ or laminæ. Darwin states, in his "Origin of Species," that the common red clover, although containing abundance of honey, is perfectly useless, owing to the length of the corolla-tube, to the hive-bee, until the tube has first been bitten through by a humble-bee. The honey of *Trifolium incarnatum*, on the other hand, is perfectly accessible to the hive-bee.

H. Müller has described, in a very interesting manner,* the mode in which hive- and honey-bees collect pollen. They first moisten it with honey before stripping it off with the brushes of their feet from the anthers. During this process the maxillæ and the labium are commonly bent beneath the breast as when at rest; the jaws are opened, and a drop of honey is spit out upon the pollen. The dry pollen of *Plantago lanceolata* (fig. 7, Pl. CXIX.) Müller saw collected by a bee in the following manner:—The bee maintains itself in the same place, immediately before the anthers, by very rapid vibrations of its wings; its sucking-apparatus is stretched forwards, but the tongue quite enclosed between the laminæ and the labial palpi; and a drop of honey is spit out from the tube on to the anthers. It then suddenly grasps the anthers with the brushes of its anterior legs, and strips off the moistened pollen on them; the dry pollen from the neighbouring anthers being also shaken out in a dense cloud. In *Plantago lanceolata* there is no honey; when pollen is to be collected from nectariferous flowers, bees retract their sucking-organs, while these organs have to be stretched out when the honey is collected. They can never therefore suck honey and collect pollen at the same time, but perform these actions alternately. There are, however, some bees, like *Andrena*, *Osmia*, and *Megachile*,

* "Nature," vol. viii. p. 206.

which collect pollen without moistening it; and these may be observed to perform both operations simultaneously.

The mode of fertilisation of the Orchideæ and Asclepiadeæ has been made so familiar by the writings of Darwin and others, that no detailed description will be necessary. With the exception of the Bee-orchis, orchids are almost invariably entomophilous; and the parts of the flowers are so arranged that in obtaining the honey from the nectary (the spur or labellum) the visiting insect — mostly some species of Hymenoptera or Lepidoptera—must necessarily strike its head or proboscis, in the first flower which it visits, against the viscid disc, so as to detach the pollinia or pollen-masses; while on entering another flower these pollen-masses are made to strike against the stigmatic surface. Fig. 6 shows at *a* a drawing of the common tway-blade, *Listera ovata*, copied from the frontispiece of Sprengel's "Entdeckte Geheimniss der Natur;" and at *b* another flower, in which the honey is being sucked from the spur by a species of ichneumon, illustrating how admirably the two long arms into which the labellum is divided are fitted for affording a standing-place to the insect while obtaining the honey.

A plant which it is difficult to place in any class in relation to the mode of its fecundation is the *Vallisneria spiralis*, of the South of France, so commonly grown in fresh-water aquaria. The pollination of the pistil is effected in this instance neither by the agency of insects nor by that of the wind, but as it were spontaneously through the medium of water. The plant is diœcious, the male and female flowers (fig. 7, *m* and *f*) being both of very simple structure and borne on different plants, often growing in close proximity to one another. The male flowers are borne on very short stalks, the female flowers on much longer spiral stalks, which have the power of coiling and uncoiling. When mature the male flowers break off from their pedicels, and, rising to the top of the water, scatter the pollen abroad on its surface, as if waiting the arrival of the female flowers, which, about the same time, also rise to the surface by the uncoiling of their pedicels. In this position some of the floating pollen reaches them and fertilises the pistil; and when this has been accomplished the pedicel again coils up and brings the female flower again below the surface of the water, where it ripens its fruit.

These examples will serve only as a few illustrations of the vast field still left for observers of the phenomena connected with the contrivances supplied by nature to favour the cross-fertilisation of flowers.

EXPLANATION OF PLATES.

PLATE CXIX.

Pollen-grains (*all* × 250).

(N.B.—1‴ = $\frac{1}{1000}$ in.)

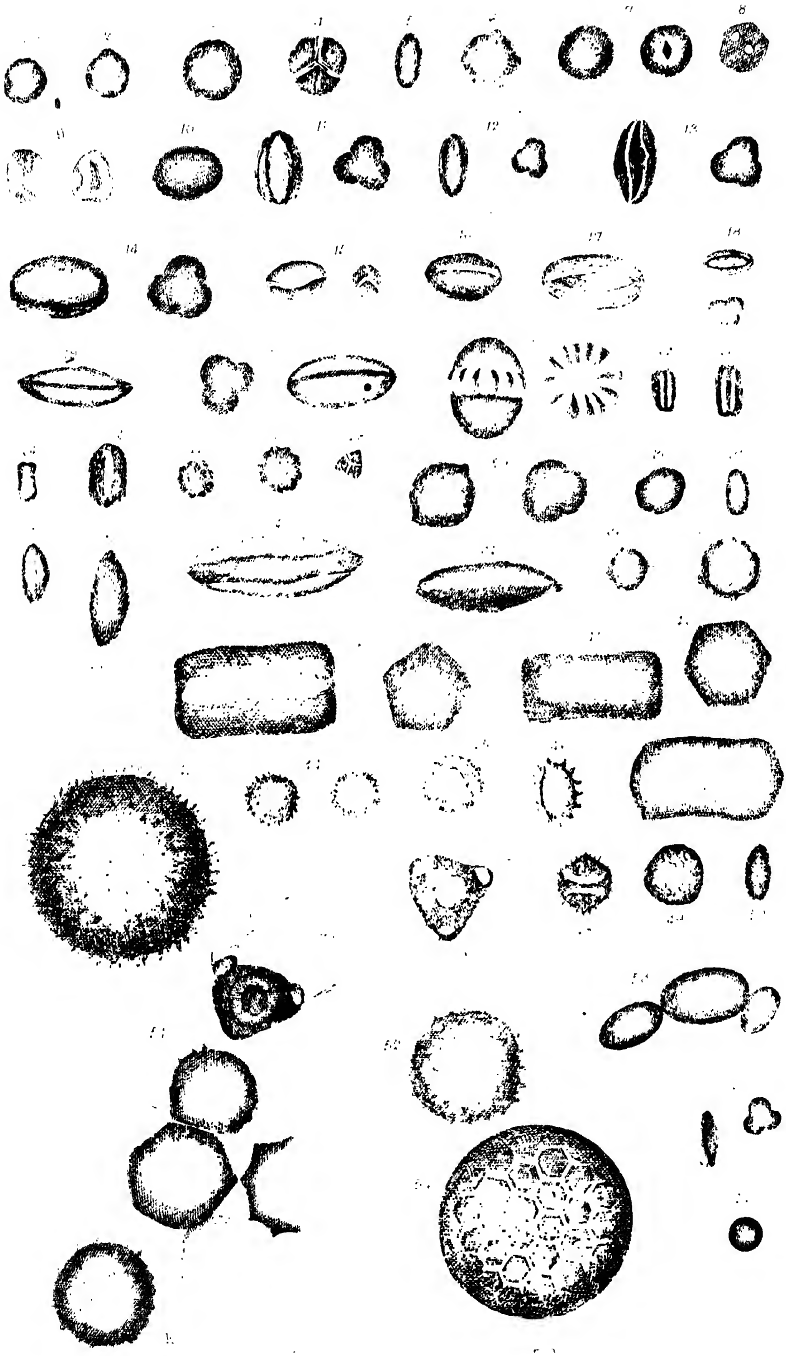
FIG. 1. *Corylus Avellana*, 1‴; 2, *Betula alba*, 1‴; 3, *Populus balsamifera*, 1·5‴; 4, *Luzula campestris*, 1·3‴; 5, *Mercurialis perennis*, 1·8‴ × 0·7‴; 6, *Buxus sempervirens*, 1·25‴; 7, *Plantago lanceolata*, 1·25‴; 8, *Poa annua*, 1·2‴; 9, *Briza media*, 1·2‴ × 1‴; 10, *Dactylis glomerata*, 1·6‴ × 1·25‴; 11, *Ranunculus Ficaria*, 1·7‴ × 1·25‴; 12, *Aubrietia deltoidea*, 1·4‴ × 1‴; 13, *Viola sylvatica*, 1·9‴ × 1·3‴; 14, *Aucuba japonica*, 2·3‴ × 1·6‴; 15, *Lamium album*, 1·5‴ × 0·7‴; 16, *Lamium purpureum*, 1·8‴ × 1·1‴; 17, *Nepeta Glechoma*, 2·4‴ × 1·4‴; 18, *Platanus orientalis*, 1·2‴ × 0·9‴; 19, *Convallaria Polygonatum*, 2·8‴ × 1‴; 20, *Bryonia dioica*, 2·7‴ × 1·4‴; 21, *Polygala myrtifolia*, 2·4‴ × 1·9‴; 22, *Primula vulgaris* (long-styled), 0·9‴ × 0·5‴; 23, *Primula vulgaris* (short-styled), 1·2‴ × 0·75‴; 24, *Primula veris* (long-styled), 1‴ × 0·5‴; 25, *Primula veris* (short-styled), 1·4‴ × 1‴; 26, *Primula vulgaris* (var. hort., Polyanthus, long-styled), 1·3‴ × 0·9‴; 27, *Polyanthus* (short-styled), 1·6‴ × 1·1‴; 28, *Primula japonica*, 0·6‴; 29, *Dicentra speciosa*, 1·5‴; 30, *Plantago media*, 1·2‴; 31, *Anthriscus sylvestris*, 1‴ × 0·6‴; 32, *Adoxa Moschatellina*, 1·4‴ × 0·7‴ × 0·5‴; 33, *Narcissus poeticus*, 2·2‴ × 1·1‴; 34, *Fritillaria imperialis*, 4‴ × 1·75‴; 35, *Fritillaria Meleagris*, 3·5‴ × 1·3‴; 36, *Ribes aureum*, 1‴; 37, *Ribes fruticosum*, 1·4‴; 38, *Hoteia japonica*, 0·7‴ × 0·4‴; 39, *Saxifraga crassifolia*, 1·4‴ × 0·8‴; 40, *Viola tricolor* (var. hort.), 3·75‴ × 2‴; 41, *Viola lutea*, 3·3‴ × 1·7‴; 42, *Viola cornuta*, 3·5‴ × 1·9‴; 43, *Althæa rosea*, 4·4‴; 44, *Cineraria*, sp., 1‴; 45, *Taraxacum officinale*, 1·25‴; 46, *Senecio vulgaris*, 1·3‴ × 1·1‴; 47, *Fuchsia*, sp., 2‴; 48, *Stellaria Holostea*, 1·25‴; 49, *Lychnis diurna*, 1·25‴; 50, *Salix nitens*, 1·2‴ × 0·7‴; 51, *Canna indica*, 2·3‴; 52, *Alpinia* sp., 2·6‴; 53, *Richardia africana*, 2‴ × 1·4‴; 54, *Cobæa scandens*, 4·6‴; 55, *Sisymbrium officinale*, 1·3‴ × 0·75‴; 54, *Pringlea antiscorbutica*, 0·75‴.

PLATE CXX.

FIG. 1. *Euphrasia officinalis*, larger-flowered form; *a*, flower just opened; *b*, position of stigma and anthers in a more advanced stage; *c*, two anthers seen from the inner side; *st*, stigma; *an*, anthers; *h*, hairs attached to the two lower anthers.

FIG. 2. *Euphrasia officinalis*, smaller-flowered form; *a*, flower just opening; *b*, position of stigma and anthers in this flower; *c*, flower in a more advanced stage; the letters as in fig. 1.

Pl. CXIX



Pl. XXI.

Insects & Flowers

FIG. 3. *Aristolochia Clematitis*; *a*, flower in an earlier, *b*, in a later stage; *st*, stigmas; *an*, anthers; *t*, tube of calyx; *l*, standard-like lip of calyx; *in*, insect imprisoned in globular cavity.

FIG. 4. Bee sucking honey from flower of *Stachys sylvatica*.

FIG. 5. Head of humble-bee, *Bombus agrorum*; *li*, ligula; *w*, membranous lobe at tip of ligula; *pl*, labial palpi; *la*, lamina; *pm*, maxillary palpi; *mt*, mentum.

FIG. 6. Flower of tway-blade, *Listera ovata*; *b*, showing an insect (ichneumon) seated on the labellum, and sucking the honey.

FIG. 7. *Vallisneria spiralis*; *m*, male; *f*, female flowers.

FIGS. 1, 2, and 5 after H. Müller; figs. 4 and 6 after Sprengel.

COLOUR STUDIES WITH THE MICROSCOPE

By HENRY J. SLACK, F.G.S., Sec. R.M.S.

A SYSTEMATIC application of the microscope to the arts of design may be strongly recommended from the extreme convenience with which ornamental forms or arrangements of colour may be brought under notice and compared with each other. It would take half-a-dozen lectures, or a good-sized and richly-illustrated volume to do anything like justice to the subject; but in the present paper a few hints may be given, more especially relating to the employment of the instrument in the study of colour, with a view to the appreciation of the principles by which beautiful results may be ensured. Colour may be studied apart from *form*, so far as its scientific aspects are concerned; but in connexion with art the two should be considered together, as the best results can only be obtained when the eye is satisfied with respect to both. Until men and women are made upon a much more uniform pattern than at present—a thing neither probable nor desirable—there will be considerable diversities of taste both for form and colour; but there will still be sufficiently broad and general agreements amongst cultivated persons to enable certain canons to be established and rules laid down. We find in architecture that no preference for Gothic over Greek, or Italian over Elizabethan, prevents the partisans of all from agreeing upon fundamental principles, which are, however, very frequently violated, either from want of culture in the architect, or, from what is more common, his being compelled to work according to the requirements of the vulgar rich. The foundation of a good style in building is that the thing should be, and look to be, mechanically correct. A ponderous structure, apparently resting upon a sheet of glass, or upon nothing at all when seen from such a position that the glass is invisible, cannot be in good taste; nor can so-called ornaments stuck on to walls or ceilings, and not in any way connected with their construction, be properly admitted. Analogous to the requisition for mechanical correctness in form, is the demand of a cultivated eye for a disposition of

colour that coincides with similar rules. No one likes, or ought to like, heavy masses of colour that are injudiciously contrasted with light tints. We often see the ugly result of inattention to this rule in wall-papers and carpets, in which huge lumps of flowers or fruits, in strong colours, are scattered over pale thin grounds; and we also see it when panels and borders are so coloured that heavy tones are put where the light would look best, and *vice versâ*, in defiance of the rule that supports of any kind should look strong enough and firm enough for the things supported. But the reader may exclaim, "What has this to do with the microscope?" Wait a bit, and it will be seen how readily experiments which would occupy weeks if made with brushes and paint can be tried in a few hours by means of the microscope and its appliances. Before, however, proceeding to the experiments, a further, though brief, consideration of the subject theoretically will be desirable.

Colours affect the eye in proportion to their masses and their luminous intensity. From physiological reasons the eye is affected by the quantity of space a given light occupies in estimating its intensity. This is easily proved by looking at a watch-face when the light is too faint for the figures to be distinguished. If only a small quantity more light would make them plain, it can be practically obtained by the use of a low-power lens. The lens takes in a larger quantity of light than would have entered the pupil without it, and though through its magnifying power it spreads the light over a proportionally larger surface, the effect upon the eye is to make every part of that surface look brighter. This is sometimes denied, but it is easily proved; and when using telescopes of even no more than three inches aperture, it is often convenient to place a delicate neutral tint glass over the eye-piece to moderate the blaze of the full moon seen through the instrument. Within certain limits, increasing the size of a surface that emits a bright colour adds to its apparent brightness, and makes a greater strain upon the eye.

The length of a wave of red light is about $\frac{1}{39000}$th of an inch; that of a wave of violet light about $\frac{1}{57500}$th of an inch, and the intermediate colours of the spectrum range between these two extremes. "The sensation of red is produced by imparting to the optic nerve four hundred and seventy-four millions of millions of impulses per second, while the sensation of violet is produced by imparting to the nerve six hundred and ninety-nine millions of millions of impulse in a second."* When the eye is strongly affected by any one colour, its nerves not only vibrate in unison with it, but they are disposed to

* Tyndall, "Notes on Light."

vibrate in unison with that opposite and complementary colour, whatever it may be, that would, in conjunction with the original colour, make up white light. As we never see one absolutely pure colour completely separated from all others, this process is not simple, and the result does not consist in one primary and one complementary vibration, but in sets of both. This action is agreeable to the eye, and consequently a sense of harmony is created by the juxtaposition and simultaneous contrast of colours that stand in this relation to each other. This is true, so far as relates to the primaries, which are conveniently considered as red, yellow, and blue,* or to the secondaries composed of any two of them. In the case of tertiary colours composed of various mixtures of the three primaries, we may start with disagreeable tints, and make them more so by this kind of contrast, or we may start with pleasant tints and improve them, as the case may be.

Many attempts have been made to compare colours with sounds, but only with partial success, although in both cases the numerical relations of the vibrations in one case to the optic, and in the other to the auditory nerves, determines whether sensations of pleasure or the reverse are produced. We may, however, use the terms *colour harmony* and *colour melody* in senses *akin* to those of the musician, though not precisely the same. Colour harmony is so far like sound harmony that it results from the simultaneous impression made by two or more colours seen at once, but it is not indispensable that the colours should, as it were, fuse together to the extent as the sounds do. In the harmony resulting from Chevreul's simultaneous contrast, each colour, or component of the harmony, stands out distinct from the other component when the masses of each are sufficiently large. There are also colour harmonies in which no single hue or tone is allowed to acquire this preeminence; the effect upon the eye is then analogous to the pleasure received by the ear in listening to harmonies of a composer like Beethoven, rendered additionally complete by a fine orchestra comprising instruments varying in *timbre* or tone-clang. In a fine landscape it is often very easy to count twenty or thirty distinct tones and hues of rock, trees, heath, soil, &c., in rich harmony; and when an artist attempts to render this with a few crude tints, the effect is little better than an attempt to play one of Mozart's Masses upon a penny whistle.

Colour melody may be used to mean something like tone melody, if we intend by it a succession of pleasurable effects in passing from one part of a picture, or artistic pattern, to

* Green has a better claim than yellow to be regarded as a simple colour, but for art purposes the common way of speaking is the best.

another. Inferior colourists in their paintings constantly sin against colour melody, by making the transition from one colour to another next to it or near to it too violent, or mutually damaging through the unavoidable physiological introduction of complementary tints. In decorative art—ladies' dresses, porcelain work, wall-papers, curtains, and furniture—the colours should be so arranged that no good effect in any part is damaged by the eye coming to it from looking at any other part.

Most of the commonplace rules, such as not to contrast a secondary with its outstanding third, will be found incorrect if the influence of quantity, already insisted upon, is taken into account. For example, instead of a contrast of green and blue being wrong, it is particularly agreeable if well made. Nature shows how to do it in such flowers as forget-me-not, nemophila, blue bells, blue irises, monkshood (pale and dark), violets, &c. Of course the pale sky-blue of the forget-me-not, and the fuller blue of nemophila, do not want the same green as the purple blue of the violets; but take the purest blue that can be found, and a corresponding green will contrast well with it if the quantities are properly studied. The same may be said of orange and blue, purple and yellow.

Equal quantities of colour in considerable masses and juxtaposed are never agreeable, and great inequalities are required to produce good effects when secondaries are contrasted with their outstanding thirds, although, contrary to what is stated in some books, there are, apart from errors of relative quantity and intensity, no inevitable colour discords except when two or more colours are so juxtaposed that their complementaries damage each other to the extent of ugliness, just as they would be injured if to each were applied a wash of the other's complementary tint.

As the object of this paper is not to offer a theoretical treatise on colour, the preceding remarks may suffice as an introduction to our experiments.

For the study of exceedingly brilliant combinations of colour, such objects as the elytron of the diamond-beetle, the Tamarisk beetle, pieces of peacock copper ore, slices of precious opal, &c., may be used with advantage, as showing what results from very striking juxtapositions. The diamond-beetle tints are best seen when the object is prepared by simply flattening an elytron, having softened it first by steaming the under surface, and then gumming on an uncovered slide. The usual balsam mounting of the opticians alters the effect. What is most remarkable in this gorgeous object is the softening influence of the blue and green, so that eyes of ordinary strength can bear with pleasure an intensity of illumination thrown upon it, that is by no means

agreeable with objects of equal lustre and a greater proportion of orange and reddish tints.

Looking at slides of these kinds can, however, scarcely be termed making experiments, unless their appearance is varied by employing tinted lights for their illumination. Monochromatic lights of course are inadmissible; but when a good beam of white light is mingled with a little of some coloured light, the effect is analogous to putting a transparent wash or glaze over a picture.

It is, however, by the use of polarized light and appropriate crystals that colour studies are best made with the microscope. It is necessary to have, in addition to the usual polarizing and analyzing prisms, a set of selenite films of different thicknesses, to vary the tints. Darker's films well mounted are the best, but another arrangement, devised by Mr. Ackland (Horne and Thornthwaite) will do exceedingly well. This consists in an ebony frame carrying a selenite plate, revolving easily by applying the finger to a toothed wheel. Above this can be placed one of three separately mounted films, marked respectively $\frac{2}{8}$, $\frac{4}{8}$, $\frac{6}{8}$, according to their wave retarding power. Each of these is readily rotated. The microscope should have a rotating stage, and the analyser mounted so as to rotate with facility.

A series of crystals of double refracting substances should be prepared either with colloid silica or a little sugar, or by such manipulation as does not allow the crystals to form until the mother fluid is in a viscid state. The silica is used by dissolving a pure water-glass in distilled water, gently adding hydrochloric acid to unite with the alkali, and allowing the resulting salt to dialize out of a parchment-paper drum, leaving 2 or 3 per cent. of pure colloid silica in solution. Those who are accustomed to chemical operations will know how to do this; others will find it best to get it done for them. Having obtained the silica solution, dissolve the salt to be crystallized in it, and prepare a slide in the usual way over a spirit-lamp, not being satisfied unless complicated patterns are obtained, and a good many tertiary tints obtainable with the polarising apparatus. These slides should be mounted with Canada Balsam.*

Let the experimenter take for a beginning an ordinary shop slide of salicine which, when the polariser and analyser are crossed so as to give a dark field, exhibits the well known circles with strong black and coloured crosses. The effect is not altogether pleasant; though it could not be called discordant,

* The sort of patterns to be obtained are shown in the plates to the author's paper on *Crystalline Forms modified by Colloid Silica*, "Monthly Microscopical Journal," March, 1871.

it is crude. No turning the polariser or analyser gets rid of this crudity, though some improvements may be made. Now introduce selenite on the stage: say Mr. Ackland's construction, using the bottom plate only, so as to get, with the right positions of polariser and analyser, a pale yellowish green tint. Two beams of the cross in the slide before the writer now appear pink, shaded; two others pale blue, and four others green, shaded and varied in tint. This is a great improvement upon the former trials, but the pattern is not a good one, and the colours look too separate to blend. A little pleasant variety is obtained by placing Ackland's $\frac{3}{8}$ selenite over the foundation one of his apparatus. With this combination some flowery patterns adjacent to the big circles and crosses come out with more variety and harmony. We find now contrasts of green or yellow, and red purple, no colour standing too sharply or in too large masses. A salicine slide prepared with colloid silica, and crystallized in elegant little rosettes, being placed in the field shows blue, yellow, orange and red, all looking crude. Revolving the analyser works no satisfactory improvement, but several positions of the polariser introduce harmony, and in some we notice elegant citron greens relieved by purples, pale tints, light yellow, and reddish brown, well disposed. This by another position of the polariser is all made ugly, through the introduction of inharmonious orange red. Beauty is again obtained by a slight left rotation of the bottom selenite on the stage, and we have sage and other greens with purples, violet, and something like primrose, well arranged.

Another richly foliated salicine slide affords amongst other tints fine bluish greys, well harmonized by their surroundings.

Cupric sulphate with silica, or by other means made to give spiral forms, rosettes, and patterns something like loosely twisted hanks of wool, affords very fine effects, abounding in tertiary tints. Cupric and magnesic sulphate crystallized together in somewhat similar patterns are also very useful. One before the writer gives, in one position of the polarising apparatus, an ugly contrast of blue, orange and golden brown badly assorted, but which can be instantly changed to sage green and other tints of great beauty by slight motion of the polariser to the left.

With the selenites arranged to give a pale neutral tint ground not differing much from white, a slide of hippuric acid in floral rosettes, affords bluish greys, dark and light; pale greeny greys, and fawns, all subdued tints, exquisitely combined.

Cadmic chloride in detached patterns, like small nosegays of various flowers and leaves, presents an admirable pattern when the apparatus gives a neutral tint ground. By varying the selenites and their position, several fine changes are obtainable.

A nearly black ground, a *gros bleu* one, and a pale blue, being among the best.

By comparing the effects produced when substances are crystallized so as to afford considerable masses of the same tints, with others in which no single tint occupies a large part of the field, but a considerable variety of tints affect the eye at once whichever part is looked at, will show how much a due proportionment of quantities has to do with artistic results. It will also be noticed that when a good effect is obtained, it will not always bear transposition to the corresponding complementary tints without the beauty being lost, and not unfrequently ugliness replacing it. This is analogous to music, which is very often spoilt by transposition to another key.

It is probable that most of the experiments described could be shown in a lecture-room by the new American lanterns and sufficiently large polarising apparatus, but private study with the microscope could not be dispensed with.

Among minerals which may give good colour lessons and suggest patterns, may be mentioned serpentine, agates, lapis lazuli, manganese crystals in talc, opalized woods, sulphur crystallized from its solution in bisulphate of carbon, &c. &c.

SAND-DUNES AND BLOWING SAND.

By W. TOPLEY, F.G.S.,

Assoc. Inst. C.E., Geological Survey of England.

THE action of the wind and waves upon our coast affords a most interesting field for study. On first looking into the subject, we cannot but be struck with the widely different effects which are produced by similar causes. We see the coast of Holderness yielding to the waves at the rate of from two to three yards per year; a few miles further south, at Spurn Point, we find that the same causes produce an oscillation of land and sea, sometimes the former and sometimes the latter gaining the mastery, but the nett result of which has been to prolong the point to the south; in other places (as at Dungeness) the gain of land is constant and rapid. We say the same causes produce the results, but it is manifest that the surrounding circumstances must vary greatly in the different cases Shingle sometimes acts as a destructive agent, being hurled by the waves against the land; elsewhere it forms a long line of defence, keeping the relative areas of sea and land unchanged; in other places the shingle accumulates, and increases the area of land.

The material with which we are now alone concerned is, at first sight, of little moment. Sand is proverbially weak and unstable, and one might well doubt if, either as a destructive or preserving agent, it could have much effect upon the advance of the sea; but plain facts show us that its effects are most important.

The space between high and low water mark varies very greatly in different parts of the coast, both as to its width and the materials of which it is composed. Sometimes it is formed of rock, sometimes of mud, shingle, or sand. When shingle is accumulating, as also in some beaches which are stationary, the whole slope is generally formed of pebble; but the more common arrangement is for the shingle to occupy only the upper part of the foreshore, generally to about mean sea level; below that

there is rock, mud, or sand. When the sand occurs only in the lower part it rarely becomes quite dry, and the wind has little or no effect upon it. But where sand occupies the whole of the foreshore, then that part at or near high water mark is dry for the greater part of the tide. The wind lifts the particles of sand and rolls them along. Where the coast is cliffy the sand is only blown against the cliff, to be again washed down by the rising tide; but where the shore is low the wind carries the sand beyond the reach of the waves, and there it accumulates: this is the origin of blown sand.

The seaward face of sand-dunes is generally steep. This is sometimes due to the base of the dune being cut away by the waves; but much the same effect is produced on the side facing the wind when the waves do not reach the hills. In no case, however, does the slope exceed 30° with fairly dry and loose sand; although the slope generally appears to the eye to be much greater than this. Dunes sometimes attain a great height. This is due to the sand being rolled by the wind along the surface and up the increasing slope, not to the wind raising the grains of sand to any height above the surface. For this reason quite a small stream of water will often suffice to stop the progress of sand-dunes. The sand is blown into the water, but not over it; and unless the sand so blown is sufficient to choke up the channel and dam back the stream, the sand cannot reach the further side. The fine dust of the desert, and of the Pampas, is carried to a great height by the wind; but this is an almost impalpable powder.

We will now describe the coast sand-hills of England, commencing with those on the north-east. The hills are nearly everywhere known as "dunes;" but in various parts of England they go by other names—as bents, downs, denes, links, greens, towans, and starr-hills; they are often called "warrens," from the numbers of rabbits which inhabit them. The commonest plant of the dunes is the "bent," or "starr-grass"—*Arundo* (*Ammophila*) *arenaria*; the long rhidome of which binds the sand, and greatly checks its movements.

The "links" of the Northumberland coast are often continuous for miles; they are usually only about 150 yards wide, but expand in some places to 300 or 400 yards. The average height of the summits is about 40 feet above mean sea level; but occasionally they rise to 60 or 70 feet. At the mouth of the little river Lyne there is a hill 87 feet high. Where these links occur, the adjacent ground is mostly flat, and the 50-feet contour line is often half a mile or more from the shore. Although these links are of so small a height, yet, rising abruptly from the flat ground, they appear to be hills of no mean elevation. Some species of plants, which occur

here in abundance, are comparatively rare elsewhere. The large, bright-red geranium (*Geranium sanguineum*) grows thickly over the landward slopes of the hills in many places; it has been recorded from but one other spot in Northumberland, and that spot is only three miles from the shore. A variety of the same beautiful flower (*G. Lancastriense*) occurs on the sands of Walney Island.

It is probable that but little alteration in the coast line of Northumberland has taken place during the historic period. Bede describes Holy Island, or Lindisfarn, as separated at every tide from the main land; although there is much blown sand there it has not shut out the tides, nor can the channel have been materially altered in the course of 1,100 years.

Durham and Yorkshire have but little sand blown along their coasts. The latter county is cliffy along its northern shore, and along the southern half the sea is making rapid inroads, which it would not do if there were barriers of sand.

There is a good deal of blown sand in some places along the coasts of Lincolnshire, and the eastern counties. In this district the term "links" is no longer used, but the hills are called "denes" or "downs." Near Lowestoft the blowing sand has overtopped, and in great part concealed, the low sea-cliff.

On the south side of the Thames the first important area of blown sand is that near Sandwich, on the north of Deal. The stratified nature of the sand is there well shown by bands of carbonaceous matter, marking former surfaces, which have been successively covered up by fresh accumulations of sand.

The great alluvial flat of Romney Marsh is a most interesting field in which to study recently-formed deposits. Here, or in its wide tributary valleys, we have alluvial silt and sand—both freshwater and marine—submerged peat and forest-beds, shingle and blown sand. The quantity of the last is but small, but it is of some interest from the relation which it has to present or past tidal inlets and mouths of rivers. Here, as along the south-eastern coast generally, the shingle travels up the English Channel, driven by the waves which are formed by the prevalent south-westerly winds. The shingle is generally arrested, or the travel largely checked, on the west or windward side of inlets; on the east or lee side of which there is frequently an accumulation of blown sand. One small patch of sand near Hythe seems to have existed in the ninth century; on the south of it there was an inlet to which tidal waters had access, and which some antiquaries have supposed to be the old mouth of the river Limen, now called the Rother. Until the middle of the thirteenth century the Rother entered the sea at Romney; it then, during some violent storms, changed its course, and went out to sea at Rye. At Romney there is blown sand on the north, or lee side, of the old channel.

At Camber, near Rye, there is again sand in a like position as regards the present channel. The sand at Camber has blown partly over the rich meadows adjacent, but is now kept in its place by vegetation.*

Patches of blown sand occur in many places along the coasts of Sussex, Hampshire, and Dorset. The most important areas are those at Christchurch and Poole; in each case the sand has had great influence in obstructing the harbours. At Christchurch the dunes attain a height of 60 feet; and towards Bournemouth blown sand caps the cliffs up to a height of 200 feet. There is some sand at the north end of the Isle of Portland, which, with the extremity of the Chesil Beach, would join the island to the main land, but that the sand is cut through by the narrow mouth of the Fleet—a tidal sheet of water which runs at the back of the Chesil Beach, between the shingle and the coast.

The shores of Devon and Cornwall, especially the northern coasts, give many examples of somewhat large areas of sand-hills, which are known as "greens" or "towans." The sand does not often reach any great height; but Mr. Pengelly states that in Whitesand Bay, near the Land's End, there is sand over the cliffs at about 200 feet above the sea. The blown sand of Cornwall is interesting from the fact that some of it was accumulated when the land stood at a lower level than now; it often caps raised beaches which are separated by a cliff of rock, 30 or 40 feet high, from the modern beach. The sand here, both of the ancient and modern dunes, is, in great part, composed of finely-broken sea shells, with many land shells intermixed. This sand is largely employed as manure, and has been so used for nearly 300 years. Sir H. de la Beche estimated in 1836 that at least 400,000 tons of sand were annually carted into the interior of the country; of this amount about one-fourth came from Padstow harbour alone. These estimates include sand recently washed up by the waves. Of the truly blown sand, that most recently formed is the most highly esteemed, this containing the largest proportion of lime. Sand which is considered worth carting contains from 40 to 70 per cent of carbonate of lime.

The Cornish blown sand is frequently consolidated into a stone, hard enough to serve for building purposes; when freshly dug it is rather soft, but it hardens by exposure, and then becomes a very durable stone.†

* The recent deposits of Romney Marsh have been fully described by Mr. F. Drew, in the Memoirs of the Geological Survey, Sheet 4; 1864.

† The human skeleton from Guadeloupe, which occupies so prominent a position in the palæontological room of the British Museum, is embedded in

The sands of the West of England have sometimes done much damage by blowing over the adjacent land. The ancient churches of Gwythian and Perranzabuloe, covered long ago by blowing sand, were afterwards laid bare by the drifting away of the sand. At Perran sands prehistoric barrows have been uncovered in the same way.

The coasts of Cheshire and Lancashire are largely protected by sand-hills, some of the land behind them being below high-water level. The hills nowhere reach any great height; between Liverpool and Southport they range to 70 or 80 feet, but elsewhere they are lower. Near Formby they cover a belt of ground nearly three miles wide; here they have made serious inroads during historic times. Southport lies amongst the dunes; and here the blowing sand frequently penetrates into the houses. In this district the dunes are called "starr-hills," "starr-grass" being the local name of the *Arundo arenaria*, which grows thickly on the sand. Mr. De Rance considers that some inland hills composed of sand—which, from a hill of that name, he has called "Shirdley Hill Sand"—are really old sand-dunes marking an old line of coast.

There is much sand on Walney Island which travels eastward, or towards the mainland, whilst the sea attacks the western coast. Further north, in Cumberland, there is some blown sand, especially near Drigg.

The sand-dunes of England have been here described in some detail, from a hope that all readers of this article may be personally acquainted with some one or other of the districts described. The dunes of Scotland and Ireland we must leave,* and pass on to consider those of greater interest and importance on the Continent.

The sand-dunes of the Atlantic coasts of Europe attain an importance of which the comparatively small hills of England give us no adequate idea. From the Pyrenees to the Baltic nearly one-half of the coast is occupied by blowing sand. Fringing the Bay of Biscay, the north-eastern part of the English Channel, and the North Sea, there are large areas of siliceous sand; on the coasts of Normandy and Brittany the sand occurs in isolated patches, and is there more or less calcareous. Brittany and the western part of Normandy strikingly resemble Cornwall and Devon in their geological structure, and not less so in the character of the superficial deposits with

a recent formation of similar character. The dune-sands near the mouth of the Nile, and of parts of the Sahara, are sometimes consolidated into stone.

* The dunes of Scotland (generally known as "links") are described by Professor Geikie in his "Scenery and Geology of Scotland," ch. iii; those of Ireland (often appropriately called "rabbit-hills") have been described by Mr. Kinahan, "Geological Magazine," vol. viii. p. 155.

which we are now concerned. Here, too, as in Cornwall, villages have been covered up by the sand. From the amount of calcareous matter which it contains, the sand often produces a fertile soil. At Cape Breton the dunes have been planted with vineyards for the last two hundred years.

On the eastern and northern shores of the Baltic there are large areas of sand; and so, too, there are along the shores of the North Sea, in a nearly continuous line, as far as the Strait of Dover. The dunes on these coasts rarely rise to a great height above the sea; 100 feet is quite an exceptional elevation; the more common height is about 40 or 50 feet. What is wanting in elevation is more than atoned for in breadth. Denmark, Schleswig, and Holstein contain together about 260 square miles of dune-sand, which sometimes extends upwards of six miles from the coast.* There are patches of sand in the Bas Boulonnais; but further south, to beyond the mouth of the Somme, the area of sand is extensive. Here, too, in travelling south, we first meet with high dunes. Near Neufchâtel (about six miles south of Boulogne) the dunes are nearly two miles wide, and attain a height of over 400 feet; possibly the sand has here accumulated over pre-existing hills of chalk.

Equal in interest to any, and second in importance to none, are the dunes of Gascony—known as "Les Landes." These extend from the mouth of the Gironde to that of the Adour, a distance of nearly 150 miles; in some places they are six miles wide, and rise to heights of over 300 feet. Until planted with fir-trees (*Pinus maritima*), about the beginning of this century, the sand was in constant motion; steadily advancing on the land, covering fields and villages on its way. The mouth of the Adour has undergone some changes in consequence of the shifting sands. Originally, as now, the river entered the sea at Bayonne; but in the sixteenth century the sands diverted its mouth to about twenty miles further north, at Vieux Boucau. It is said that the inhabitants of Bayonne made a passage through the sand, thus restoring the river to its former course and their city to its old importance.

It is doubtful to what extent, if any, these and similar dunes were originally wooded. It has been supposed that during the times of the old forest growth they were covered with trees which have been mainly destroyed by man. But if this were so, we should expect to find some traces of the old forests brought to light during the more modern shiftings of the sands.

* For this statement, as well as for much of the information which follows, I am indebted to the valuable work of Mr. G. P. Marsh, "The Earth as modified by Human Action" (a New Edition of "Man and Nature"), 1874.

But however this may be, it is certain that until within the last sixty years, and for centuries before that, the Landes have been nothing but waste blowing sand, a terror to the cultivators of the fertile soil on their eastern side. When the Moors were finally driven from Spain, they asked permission to live in this desert, which they would reclaim: this request was refused. Possibly we may form some idea of the material loss which France inflicted on herself in thus rejecting what Spain had not the wisdom to keep; but no one can estimate the intellectual loss which Europe has sustained in the forced extinction of Arabian science.

There is much sand along the south-west and south shores of the Mediterranean Sea. The dunes only fringe the seaward face of the plains of Sharon and Philistria, spreading over a somewhat wider space near Joppa; but they become of much greater importance farther south, and they form a broad zone of hills, sometimes ten miles wide, along the northern margin of the delta of the Nile. Much of the coast of Barbary is bordered by sand-hills; in some places these are backed by fertile plains, but elsewhere they blend with that vast inland sea of sand, the great Sahara.

An enormous arid area extends from the West Coast of Africa, across the Sahara, the Libyan Desert, the Peninsula of Sinai, the Syrian Desert, the valleys of the Euphrates and Tigris, through Persia, and far into Central Asia. Throughout this vast expanse of country there is an exceedingly small rainfall, so small that in some physical maps it is coloured as a "rainless district," and such in some parts it probably is. There is necessarily little or no vegetation to cover the rock and preserve the soil. There is a large proportion of sandstone strata (of different geological ages) along this line, which, yielding to the powerful influence of a tropical heat,* and to atmospherical agencies, produce a large quantity of loose sand. If there were sufficient rainfall to feed permanent streams, the *débris* of the rocks would be gradually carried away; but this not being the case, the sand remains, and becomes the sport of every gust of wind.

There can be little doubt that this is the origin of much of the sand of the desert; not, perhaps, of all. There is abundant evidence that the Sahara has been covered by the sea at quite a recent geological date, and large quantities of the sand which covers it may date from that period. Some, too, has been derived from the present sea-bed; first as coast-dunes, afterwards being drifted inland.

* Although from 15° to 30° north of the equator, Nubia, with the desert to the west, and Central Arabia, form the hottest district in the world.

The phenomena presented by coast-dunes are repeated by the sand-hills of the desert. They are steepest on the side which faces the wind, and the sand often blows into curious crater-like forms, somewhat resembling volcanic cones, one side of which has been blown away. The crater-like shaped hills would appear to be more perfectly formed in inland deserts than on coast-dunes.

Although the surface of sand-hills and sand-deserts is so bare and arid, water may frequently be found at no great depth. In coast-dunes the sand is generally quite moist just below the surface. Where the shape of the dunes is constantly changing, fresh sand being blown up from the shore, the water is often brackish, but in fixed dunes the water is generally quite fresh. If the sand cover any wide area, and especially if it be underlain by an impervious bed, such water may often be got in fair quantity. All this may be easily explained by the rain falling on the sand and being here retained, partly between the grains of sand, and partly held up by the underlying clay.

But it is not so easy to understand how large quantities of water are stored beneath the sands of the Sahara, nor the source from whence the water is derived. The Moors have for long ages been aware of the existence of this store of water, and they have dug wells through the sand to reach it. The water occurs at various depths, but it generally rises to the surface when the water-bearing bed is reached. The French engineers have made a great number of bore-holes in various parts of the desert. The quantity of water thus obtained is often very great. One bore-hole yielded nearly 1,500,000 gallons per day; the water of this was employed to turn a water-mill. Small fish are sometimes thrown up with the water of these wells and bore-holes. The same fish occur in surface pools of water; it seems therefore probable that there may be some communication between the pools and the water-bearing stratum.*

Partly from a want of vegetation, and partly from its greater dryness, the sand of inland deserts is more easily moved by the wind than is the sand of the coast. In the deserts of Peru the crescent-shaped hillocks of sand are called Medanos. They are "from ten to twenty feet high, and have an acute crest. The inner side is perpendicular, and the outer or bow side forms an angle with a steep inclination downwards. When driven by violent winds the medanos pass rapidly over the plains. The

* Professor Ramsay suggests this in a note to his translation of Professor Desor's *Memoir on the Sahara*, "Geological Magazine," vol. i. p. 27. For further details on this most interesting region, see Rev. H. B. Tristram's "Great Sahara," 1860.

smaller and lighter ones move quickly forward, before the larger; but the latter soon overtake and crush them, whilst they are themselves shivered by the collision. These medanos assume all sorts of extraordinary figures, and sometimes move along the plain in rows forming most intricate labyrinths."*

Even more remarkable than the medanos are those tall revolving columns of sand which are sometimes seen in the deserts of Africa and Australia. The sand is taken up by the whirling wind, and is carried along like a waterspout. Several such columns are often seen at the same time; they travel at a great speed, the lower ends touching the ground. Sometimes obscuring the sun, sometimes glowing in its rays, they seem to be veritable pillars of cloud and fire. It was a sand-storm with columns of sand such as these which played terrible havoc with the army of Cambyses in the Libyan desert.

Baddeley, in describing the dust whirlwinds of northern India, says:—"A broad wall of dust is observed advancing rapidly, apparently composed of a number of large vertical columns, each preserving its respective position in the moving mass, and each column having a whirling motion of its own."

The continuous action of blowing sand wears the rocks in a peculiar manner. Mr. Bauerman thus describes the sands of part of Arabia Petræa:—"Sand-scored stones are abundant everywhere. . . . . As a rule, the hardest rocks are the best polished—this being more especially the case with quartz, jasper, carnelian, and similar siliceous substances; while the limestones, in addition to being polished, are furrowed and scored in every direction, and their surfaces studded with numberless small reticulating grooves, resembling the hill-shading on a topographical map."

A similar polishing action is apparent on the harder rocks of our own coasts, where these rocks are exposed to the wear of sand. Professor Ramsay has suggested that the mushroom-shaped and undercut rocks, which are so characteristic of many sandstone areas, may have been worn into their present shape by the action of wind, blowing the loose sand against the under surfaces of the rocks. No one who has visited such rocks during high winds will doubt that the wind and sand are capable of so cutting out rocks.

The erosive action of sand, when let fall in a continuous stream, or propelled by means of a blast, has been turned to account during the last few years in etching or deeply graving glass and metal; the effect is singularly sharp and beautiful.

* Tschudi's "Travels in Peru," ch. ix. (quoted by Marsh, p. 602). The inner side of the hillock can only be "perpendicular" when the medanos are in motion.

All who have passed much time on sandy shores, or among sand-dunes, must have remarked the peculiar whistling sound produced by the friction of the particles of sand against each other. Similar sounds, but far louder, are produced when dry sand runs down a slope. Captain H. S. Palmer has described such sounds as heard at Jebul Nágús, near Mount Sinai. Coarse sand, derived from the waste of the sandstone hills, is carried by high winds up the slope of the hill; here it lies at the angle of rest (30°), and the slightest cause is sufficient to set it in motion. Sometimes the sound is as soft and low as the hum of a humming-top; sometimes it almost approaches the roar of thunder.

THE COLORADO POTATO-BEETLE.

By W. S. DALLAS, F.L.S.

[PLATE CXXI.]

IN ancient times men noted especially the injuries done to their property by their larger and more powerful enemies. It was the boar that came out of the wood to lay waste the vineyard, and the wild beasts of the field that ruined the hopes of the husbandman. At the present day, in all civilised communities, the number of such destroyers is greatly limited; but on the other hand we are compelled to recognise a multitude of minute enemies, which make up for their smallness by their great abundance, and perhaps are all the more mischievous by reason of their individual insignificance. Among the foes of the agriculturist which have come into notice of late years, the insect which has been called the "Colorado Potato-bug," has not only attracted a good deal of attention in America, where it has inflicted serious injury on the potato crops, but has also raised considerable apprehensions on this side of the Atlantic; circumstances which may justify us in giving some account of its appearance and natural history.

This beetle was discovered by Messrs. Say and Nuttall during an early American exploring expedition in what was then known as the "Far West," on the banks of the Upper Missouri, towards the foot of the Rocky Mountains. It was described by Say in the third volume of the "Proceedings" of the Academy of Natural Sciences of Philadelphia, published in 1824, under the name of *Doryphora 10-lineata*. For many years afterwards nothing was known of it except that such a beetle did exist, its true home being among the Rocky Mountains, where it feeds upon a wild solanaceous plant (*Solanum rostratum*, Dunal) peculiar to that region. But during all this time the advance of a civilised population was going on with astonishing rapidity in the direction of the Rocky Mountains, converting the vast region west of the Mississippi—which in 1824 was still a wilderness inhabited only by Indians and hunters—into a more or less

settled and cultivated tract, and the settlement of the territory of Nebraska carried cultivation, and with it the potato, into the district inhabited by the *Doryphora*. The insect was not long in taking advantage of the abundant supply of suitable food thus offered to it. In fact, we may with some justice assume that it found in the cultivated potato a nourishment better adapted to its wants than that furnished by the native plant on which it had previously fed; for it seems to have set out almost immediately in the direction of the more highly cultivated districts, and spread eastward with great rapidity.

In the year 1859 it was still far west, being then at a distance of 100 miles west of Onaha city, in Nebraska; but within two years (in 1861) it reached the state of Iowa, over which it spread completely in about three years, and in 1864 and 1865 did great mischief to the crops. During these years the beetles were also very destructive in the state of Missouri, and in 1864 and 1865 they crossed the Mississippi and invaded Illinois in great force, causing much injury to the potatoes in the north-western part of that State. A branch migration northwards commenced in 1862, when the beetle made a settlement in the south-west corner of Wisconsin; by 1866 it had spread over the whole State. During the next two years it completed its occupation of Illinois, and in 1867 passed thence into Indiana and the south-west angle of Michigan, where it was very abundant in 1868. In this year its presence was noted in Pennsylvania, but it was not until 1871 that the Quaker State was fairly invaded by the western beetle. In this year the beetles swarmed about Detroit, at the south-eastern angle of Wisconsin, and great numbers of them are said to have been carried down with floating rubbish and on board ship into Lake Erie, to be wafted along that sheet of water and landed on the Canadian shores, and on the shores of New York and Pennsylvania at the opposite end of the lake. In 1871 also it was reported as doing mischief to the potatoes in Ohio; and in 1873 it had crossed Pennsylvania and reached the district of Columbia, near Washington, and almost to the shores of the Atlantic near Baltimore. In the meantime the northern migration had carried the pest through Wisconsin into Minnesota and Dakota; and through Michigan into Canada, where it made its appearance in 1870. Its transportation into Canada was in part effected by means of the shipping on the lakes. In the south also Kentucky and western Virginia were invaded in 1871 and 1873.

In the year 1868, when the western potato-beetle had reached the centre of Indiana, Mr. B. D. Walsh estimated the rate of its advance at about 60 miles a year, and upon this foundation predicted that it would reach the Atlantic coast

about 1878. The insect has contrived by some means considerably to outstrip the prediction, and between 1871 and 1873, at any rate, it must have passed over nearly 300 miles of country. This astonishing rate of progress can hardly be due to the insect's own exertions, and it seems probable that the rapidity with which it appears to be spreading in the densely populated eastern States must be owing to the increased traffic in these districts offering additional facilities of artificial transport.

A striking point in the history of this unwelcome occupation of the cultivated low grounds of North America by a mountain beetle is that it has taken almost a direct easterly route across the continent, and that its advance has been at all times more rapid in the northern than in the southern districts. The American entomologists who have written most fully upon this beetle, Messrs. Walsh and Riley, remark especially upon this point; and the former compares the advance of the insects through Illinois to that of General Sherman's army in the late war, and says that "the southern columns of the grand army lag far behind the northern columns."

According to Mr. Riley this peculiarity is to be accounted for by the supposition that the western potato-bug being essentially an Alpine species, thrives best and therefore spreads most rapidly in the cooler northern regions, and this view is borne out by the fact that even in the north a very hot summer destroys the insect.

Of the actual extent of damage done to the potato crops in the districts which have been visited by these destructive insects we have no precise information, the only approach to an estimate being that of Mr. Walsh, who stated the probable loss by this cause in a small district at about 1,750,000 dollars. From the nature of the case, it is perhaps almost impossible to arrive at any exact computation. Nevertheless, the statistics published annually by the United States Department of Agriculture seem to indicate a falling off in the potato crops, which may be due to the ravages of the *Doryphora*. Thus, the total production of potatoes in all parts of the United States was as follows:—

	Bushels.		Acres.	Average per Acre.	
In 1868	106,000,000	from	1,131,552	94	Bushels.
In 1869	133,886,000	„	1,222,250	109½	„
In 1870	114,775,000	„	1,325,119	86	„
In 1872	113,516,000	„	1,331,331	85	„

The year 1869 seems to have been an exceptionally favourable one for the growth of potatoes in all parts of the Union. Indeed, in Michigan, which had already been invaded by the Colorado beetle, the yield reached the enormous average of 155

bushels per acre. But when we examine the production of the individual States, taking some in which the Western potato-beetle had made its appearance in force in the above years, and others which had either remained uninvaded or been only partially attacked at the same time, we get the following as the average produce per acre in bushels:—

	1869.	1870.	1872.
New Hampshire	150	88	94
New York	114	98	88
Pennsylvania	93	87	90
Missouri	115	103	80
Illinois	103	81	75
Ohio	112	72	80
Michigan	155	95	66
Minnesota	112	57	99

In general terms, we may say that the falling off is greater in those States which the beetle had fully occupied; but it is evident that other causes of fluctuation must be at work to give rise to the variation in the amount of produce. Still, although the mischief done by the beetle may have been exaggerated, it is certain, from all accounts, that it is by no means inconsiderable, and the recovery of the crops in some of the States which suffered most from the early visitation of the insect is directly ascribed by the Government statistician to the vigorous warfare which has been waged against it by the farmers.

The beetle which has inflicted so much damage, and caused so much alarm in the United States, that the prospect of its succeeding in crossing the Atlantic has raised almost a panic in some European countries, is by no means a formidable animal to look upon. It is a beetle of the tribe of Phytophaga, or plant-eaters, and of the family Chrysomelidæ, all the members of which are of small or moderate size, of a rounded, ovate, or oblong convex form, with the head short and deeply sunk in the next segment (prothorax), the antennæ generally thread-like or beaded, and only of moderate length, and the tarsi (feet) with only four apparent joints. The insect, as already stated, was described in 1824 by Thomas Say as belonging to the genus *Doryphora* ("spear-bearer"), in which the meso- and metasterna are produced forward into a spine; this is the origin of the name of the "ten-lined spearman" given to the insect by Mr. B. D. Walsh. The genus *Doryphora* has been considerably subdivided by recent authors, and by some entomologists the species under notice is referred either to the genus *Polygramma* of Chevrolat or to *Leptinotarsa* of Stål, in which the sternum is unarmed (fig. 4); but it will be sufficient for our present purpose to speak of it under the old name of *Doryphora decem-lineata*.

The perfect beetle (fig. 3) measures from two-fifths to half an inch in length, of an oblong-ovate form, and of a tawny or yellowish-cream colour, adorned with numerous black spots and stripes. Of the former, a very peculiar group, consisting generally of eighteen, occupies the upper surface of the prothorax, or segment immediately behind the head. These consist of two elongated spots or short lines in the middle of the surface, a row of four small spots along the hinder margin, and usually six similar points on each side of the two middle ones. On the wing-cases (elytra) we see ten black stripes, five on each—namely, one close to the line of junction of the two wing-cases, and one close to the outer margin, both of which stop rather far from the apex of the wing-case, and three between these, reaching nearly to the tip. The edges of all these black stripes are irregularly punctured, the punctures being partly on the stripes and partly on the intervening pale surface, and the second and third stripes from the suture are in contact with each other at the base and apex (see fig. 5). The legs have the knees and the feet (tarsi) black. Beneath the elytra the insect is furnished with ample membranous wings, which it uses freely, and they are described by American entomologists as of a fine rose-colour, and as giving the beetles a very beautiful appearance when flying in the sun.

The species appears to be pretty generally diffused in the Rocky Mountains, from the eastern slope of which it has invaded the cultivated regions by the course already described. Although found in the Colorado territory, it is by no means peculiar to that district, and the name of "Colorado potato-bug" commonly given to it does not indicate the locality from which it set out on its eastward journey.

Although several American entomologists of repute (such as Messrs. Walsh, Riley, and Shimer) have devoted considerable attention to the habits of the Colorado potato-beetle, its history, at least in one important point, has not been very satisfactorily worked out. There appear to be three generations of the beetles in the year. In the spring, when the potato-plants are quite young, the perfect insects produced from the last generation of the previous year lay their eggs upon the under surface of the leaves in small patches of from twenty to thirty together (fig. 1, *a*). The number of eggs produced by each female is said by some writers to be from 700 to 1,200, but this is probably an exaggeration. The eggs are of a yellowish colour. They hatch in about six days. The larvæ (fig. 1, *b*, *c*, *d*), which are at first of a reddish colour, grow rapidly, and become lighter in tint (of a more or less reddish cream-colour, or orange); they are full-grown in from seventeen to twenty days. In the mature state (fig. 1, *d*) the larva is a thick fleshy

grub, about half an inch long, having the head and the anterior segments narrow, the first three segments of the body furnished with jointed legs, and the extremity of the abdomen with a short process (anal proleg), which serves the animal as an additional limb in adhering to the plants on which it feeds. The head, the hinder margin of the first body-segment (prothorax), and the legs are black, and two rows of black spots are to be seen along each side of the body.

In many, if not in most of the insects belonging to the family Chrysomelidæ, the anal proleg of the larva serves another purpose besides that of assisting its progression; it produces a viscid secretion, by which the larva fixes its tail to the surface of a leaf or other object before passing into the quiescent pupa state. There has been some discussion among American entomologists as to whether the Western potato-beetle ever employs its proleg in this manner, and the question does not seem to be quite satisfactorily settled; but Messrs. Riley and Shimer—the former of whom claims to be the first who ascertained the history of the insect through all its changes—maintain that it never undergoes its pupal transformation attached to the plant on which it has been feeding, but always descends to the earth, and under its protection sleeps out the pupa stage. In this state (fig. 2) the insect is a small oval body, roughly showing at its surface the forms of the various organs of the perfect beetle (head, legs, elytra, &c.), folded together and confined by a skin, which will be thrown off when it emerges as a beetle. The insects of the first and second broods of each year remain in this condition ten or twelve days, when they issue forth as perfect beetles, and the females quickly proceed to lay their eggs upon the potato-plants. How long the pupæ of the third or last brood continue without further development does not appear to be very clearly known; but all recent observers agree that the perfect insects are produced before or during the winter, and that they remain underground until the spring. It seems to be certain that the beetles are found fully developed in the ground during the winter, although their descending to a depth of eight or ten feet, as stated by Mr. Riley, seems quite incredible, considering the form and structure of the insect. The same writer, however, says that they seldom go down below eighteen or twenty inches; probably they generally remain within the portion of ground which has been broken up in digging the potatoes, as this would furnish them with ample protection against the direct influence of cold, and the beetles would have no difficulty in making their way between the clods to a suitable shelter.

A curious quality has been ascribed to the Colorado potato-beetle, and, according to Mr. Riley, upon authentic evidence in

some cases. They and their larvæ are said to possess poisonous properties which have been known to affect people handling them, and to produce serious illness in those who have inhaled the vapours given off during the operation of scalding large quantities of the larvæ, or burning potato-haulms infested by them. Even the birds and domestic poultry were said at first to refuse to eat them; and in one Report we are told that the prairie hens alone would touch them, but that the flesh of the birds was rendered so unwholesome by this diet that it could no longer be eaten with impunity. We may suspect some exaggeration in these statements, especially as we find at a later period of the visitation that several farmers found their fowls feed freely upon the larvæ, and even recommended the cooping of chickens in the potato-fields as a means of checking the pest. Other birds also have probably accustomed themselves by this time to the taste of this novel food; at least, it has been observed in some parts of Iowa that the rose-breasted grosbeak (*Guiraca ludoviciana*) feeds freely upon the larvæ, and although this bird was formerly rather rare, it has now become plentiful in the district.

But if the birds have been inclined to fight shy of the western beetle, it has met with an abundance of insect foes in the course of its invasion. Among those which have rendered themselves prominent in this warfare, several species of lady-birds devour the eggs of the beetle; a tiger-beetle (*Tetracha virginica*), and several Carabidæ, eat the larvæ; a wasp (*Polistes rubiginosus*) carries them off to its nest to furnish provisions for its young; an Asilide fly (*Promachus Bastardii*), and several species of true bugs (*Rhynchota*), especially a *Harpactor* and an *Arma*, pierce the larvæ with their beaks and suck out the juices; whilst a Tachinide fly (*Lydella Doryphoræ*, Riley) attacks them by the insidious method of parasitism, depositing an egg upon the surface of the larvæ, generally near the head, the young parasite produced from which burrows into the body of the victim and feeds upon its substance, not destroying it, however, until after it has descended to the ground when full grown. A long-legged spider or harvest-man (*Phalangium dorsatum*) is also described as feeding upon the larvæ in some districts; and the beetle has been found infested with adhering mites like those so constantly seen on our common dung-beetles (*Geotrupes*).

From the published Reports it would seem that these insect-enemies of the potato-beetle being mostly natives of the soil, have exerted their powers of destruction so vigorously against the western invaders as to have greatly checked their multiplication, the numbers of the carnivorous species having increased with a rapidity proportionate to the abundance of nourishment

offered to them. In the long run probably a balance would be arrived at between the contending forces, but in the meantime the crops would be seriously affected, and the country would still always be liable (like our hop-gardens) to the occasional excessive multiplication of the destructive insects. Indeed with every confidence in the ultimate establishment of a balance of power between the western beetle and its enemies, the farmer could hardly be expected to look on with equanimity while his potato-fields were being ravaged; and it is not surprising to find that the most various methods—some most absurd, others more or less judicious—of getting rid of the pest, should have been adopted. Of actual remedies—that is to say, means of destroying the insect after it has taken possession of the potato-plants—the best seem to be the use of sweeping and beating nets, or substitutes for the latter, into which the insects are beaten by some implement, such as a flat broom, and the dusting of the plants with a poisonous powder composed of Paris or Scheele's green (arsenite of copper), mixed with from twelve to fifteen times its weight of flour or plaster of Paris. It is found that the use of this poison does not render the potatoes produced by the plants treated with it unfit for food, but it seems still to be doubtful whether the potatoes grown afterwards in soil upon which it has been employed are not injured in their quality, and Mr. Riley strongly recommends that it should be used as sparingly as possible. In his opinion, the most valuable remedial measures consist in the adoption of certain precautions in the selection of sorts for planting, and especially in the exercise of great vigilance in the spring of the year, placing in the newly-planted fields small heaps of potatoes to which the beetles are attracted on emerging from the ground, and from which they may easily be gathered every morning, and destroying as many as possible of the eggs and young larvæ of the first brood. By these means it would appear that the increase of this new scourge of the potato may at least be considerably checked.

At the same time there is one circumstance in the history of the insect which will probably stand in the way of its being effectually controlled. In their progress through a civilised country the beetles have cast off the simplicity of their western ancestors, and having once changed their food-plant, have now tried many other articles of diet, and found some of them highly congenial to their taste. Besides various Solanaceæ growing wild, they have been observed feeding on species of *Echinospermum*, *Amaranthus*, *Helianthus*, *Cirsium*, *Sisymbrium*, *Polygonum*, *Chenopodium*, *Eupatorium*, and *Hyoscyamus*, and on grass, oats, the red currant, and even the cabbage. This plasticity of appetite, if it may be so termed, acquired by an

insect which, in its original home, seems to confine itself strictly to one species of plant, is a fact of considerable zoological interest.

But this is not the only curious point in the natural history of the Colorado potato-beetle. It undoubtedly started on its eastward migration from the lower parts of the eastern side of the Rocky Mountain range, and probably the direction of its movement has been governed to a certain extent by that of the prevalent winds. But it is singular not only that the *Doryphora* is unknown as a potato-eater west of the Rocky Mountains, but that according to the testimony of the inhabitants of the Colorado territory and other elevated parts of the range, the beetle is there perfectly true to its original food-plant (*Solanum rostratum*), even in localities where potatoes are cultivated. And this fact becomes still more remarkable when we learn that the older States, especially towards the south, are inhabited by a species of *Doryphora*, very nearly allied to the potato-beetle, which feeds upon the so-called horse-nettle (*Solanum carolinense*), and has never yet been known to attack the cultivated potato, although grown in its neighbourhood for many years. This beetle, which has received from some American writers the euphonious name of the "Bogus Colorado Potato-bug," from its having been frequently mistaken for the true malefactor, is the *Doryphora juncta* of Germar. It agrees closely with the *Doryphora* 10-*lineata* in size, form, and general character, having the same number of black spots similarly arranged upon the prothorax and the same number of black stripes upon the wing-cases; but it may easily be distinguished on close examination by its having the black stripes of the elytra margined by an impressed line (stria) containing a single row of punctures (fig. 6); by the third and fourth stripes, counting from the suture, being united at base and apex; and by the legs being entirely pale, except a small black spot on the middle of each thigh in front. The larva also, although very similar to that of the potato-beetle in form, is of a lighter colour, has the whole of the first body-segment (prothorax) black, and only a single row of black spots along each side of the body. The presence of these two beetles side by side in the United States, their close agreement in external characters, and their difference in habits, may be expected to open a wide field of investigation in connexion with the question of the origin of species. We may obtain some valuable data if American entomologists will carefully collect every year specimens of *Doryphora* 10-*lineata* from various localities, so as to compare them, after some time has elapsed, with specimens of the same species from its original mountain home.

There is one other matter in connexion with this new foe to

the potato which must be alluded to here; namely, the chance of its being introduced into Europe. Considering the alarm that the gradual advance of the potato-beetle has produced in America, it is not surprising that some apprehension should be felt on the subject on this side of the Atlantic, or that the authorities of some Continental States, to which the importation of American potatoes is of far less consequence than it is to us, should be debating the propriety of prohibiting all such importations. But if we consider the natural history of the beetle, as already described, it will be seen that there is little cause for apprehension upon this score. At the time of digging the main crop of potatoes, the insects will certainly be in the ground, probably in the pupa state, and if so a little care in washing them clean from all adherent soil before shipment will suffice to remove any pupæ which may by chance be entangled in the earth. The perfect beetles will be still less likely to be transported with the potatoes.

The real danger for Europe, as Mr. Riley has pointed out, consists in the possibility of perfect beetles, especially fecundated females, finding their way on board ships or steamers bound across the Atlantic; and the experience of the transportation of the beetles by means of trading-vessels across the lakes from Michigan into Canada and the eastern States, shows that there is at least a possibility of their being introduced into Europe by similar means. This is a possibility against which no custom-house regulations, and indeed no official vigilance of any kind, can guard, and the only precaution that we can take is that recommended by the excellent American entomologist just cited; namely, the circulation among seafaring men and the inhabitants of our western shores, and the posting up in the cabins of sailing-vessels and steam-boats, of correct descriptions and coloured figures of the beetle, with the request that anyone seeing such a creature on board ship or elsewhere should immediately destroy it. Considering the magnitude of the interests involved in this matter, although perhaps there may be no great cause of alarm, it is not too much to expect that the Government should co-operate with the various agricultural societies in spreading trustworthy information about the western potato-beetle throughout the country, and also take steps to carry out the suggestion of furnishing ships trading to America with conspicuous notices of the kind alluded to above.

DESCRIPTION OF PLATE CXXI.

Fig. 1. Portion of a Potato-plant, with the Colorado Potato-beetle (*Doryphora* 10-*lineata*) in the egg (*a*), larva (*b*, *c*, *d*), and imago (*e*).

Fig. 2. Pupa, of the natural size.

Fig. 3. Imago, of the natural size.

Fig. 4. Underside of the imago.

Fig. 5. Left wing-case, enlarged, showing the arrangement of the black lines; *a*, outer margin.

Fig. 6. Left wing-case of *Doryphora juncta*, enlarged, showing the arrangement of the black lines; *a*, outer margin.

THE ARCTIC EXPEDITION: ITS SCIENTIFIC AIMS.

By ROBERT BROWN, M.A., Ph.D., F.L.S., F.R.G.S., &c.

BEFORE the next part of this review is in the hands of its readers an English expedition—the object of which is to explore the wide unknown region surrounding the North Pole—will be well on its way to the scene of its labours for the next two years. An event so remarkable in the annals of science cannot be allowed to pass unnoted. For months past almost every journal in the kingdom has had something to say on the subject; for years to come we shall hear talk interminable, or may read print of which there is no end on this fruitful subject. Judging from the past we may expect these articles to be plentifully distinguished for the want of knowledge, more especially of what are the scientific aims and objects of the expedition. A few pages may be therefore profitably devoted to this question. Thanks to the unwearying efforts of Sherard Osborn and Clements Markham, backed by the Arctic Committees of the Royal and Geographical Societies, and their refusal to accept a denial—*sedunt æternumque sedebunt*—in a few weeks the ships and the men will be ready. The *Alert* and *Discovery* are now fitting out at Portsmouth with every appliance which experience and ingenuity can suggest as best fitted for serving the purposes for which they are intended. Twenty-three officers have been selected from the overwhelming number of volunteers who offered themselves. The head of the whole expedition will be Captain Nares, of *Challenger* fame. Commander Albert H. Markham, who has shown that his skill as a naval commander in many seas is almost equalled by his literary power in describing his voyages, is second in command; while Captain Stephenson, late of the Royal Yacht, will have the command of the second ship. Under these officers will be about 120 seamen. In addition there will be six ice-masters—experienced whalemen—who will advise the officers on questions connected with ice navigation, and two civilian naturalists. It is to be hoped that one of these is a geologist; for, as we shall see presently, the geological questions to be solved are not the

least important of all those which await the labours of these gentlemen. Altogether he would be a carping critic who would cavil at the arrangements of this expedition, or its *personnel*. By the end of May it is believed that it will be ready to sail. In a fortnight or so after it will be sighting the coast of Greenland. It will now enter Davis' Strait, and after touching one or two of the little Danish posts on that dreary coast, it will sail into Baffin's Bay, and then into Smith's Sound, the "threshold of the unknown region." The exploration of this Sound has been advanced by the expeditions of Kane, Hayes, and Hall; and the chief aim of this expedition, geographically, will be to reach and explore a latitude beyond that attained by the last-named and ill-fated commander. How this is best to be accomplished may be safely left to the judgment of Captain Nares himself. Speaking broadly, the plan at present proposed is for the two ships to push north up Smith's Sound, or its continuation, to a point as far as the season, or the ice, will permit. One of the ships will remain in this locality, while the other will push still further on if possible, and explore, by boats or sledges, as circumstances may show to be best, the sea and lands lying beyond. In case of disaster the depôt vessel will afford the adventurers a home to fall back upon. It is, however, unnecessary to say that the details of such plans must be altered indefinitely, and that it would be most unwise to strangle the skill of a commander, who has already shown himself so worthy of trust, by the bonds of red tape, which cut-and-dry "instructions" would assuredly be.

What, then, are the objects of this expedition? In the first place, it is the only expedition—since the unfortunate one of Sir John Franklin in the *Erebus* and *Terror*—which the English Government has despatched to the Arctic seas for exploration alone. Since 1845 numerous ships flying the pennant have been within the Arctic circle, and have greatly enlarged our knowledge of the circumpolar regions. But they were in search of the expedition of Franklin; discovery was not one of their objects; and though they might have incidentally advanced science, provision was not made for research; and, indeed, so long as the mission they were sent on was unfulfilled, no man dared to think of science or of geographical exploration, brilliant though some of the discoveries made, no doubt, were. Need I remind the reader that on one of these expeditions the North-west Passage was discovered?

But the adventurers in the *Alert* and *Discovery* will have no thought to divert their minds from exploration in the widest sense of the term. Every provision has been made for it consistent with that economy of space which the storage of such a large quantity of fuel and provisions demand. Unlike the case of the

Challenger, there are no posts to visit, where stores can be taken or surplus baggage left. All must be at once taken from England; on this they will have to draw for the whole term of the expedition. The land and seas they are to explore are dreary enough, and an idea obtains that there is really nothing to be done in these far northern lands; that no interest attaches to them from a scientific point of view; and that the naturalists of the Arctic expedition, after they have surveyed their home in the far North, may sit down on its frozen shores and weep, if they are so inclined, because there is there no world for them to conquer. Around the Pole there are about 2,500,000 square miles of sea and land yet unknown, and lying virgin for exploration. It must not be supposed that the mere vainglory of reaching the spot known as the North Pole is the object of the equipment of this expedition. "The North Pole," writes Mr. Clements Markham (I quote the *ipsissima verba* of this eminent geographer because I can find none of my own which more fully expresses the meaning which I wish to convey), "is merely a spot where the sun's altitude is equal to its declination, and where bearings must be obtained by reference to time and not to the magnet. It will doubtless be reached in the course of exploration, and there is something which takes the imagination of ignorant and uncultivated persons in the idea of standing upon it. But this will not be the main, or even a principal result, of the expedition. The objects in view are the discovery of the conditions of land and sea within the unknown area, and the investigation of all the phenomena in that region, in the various branches of science. These results can only be obtained by facing difficulties, perils, and hardships of no ordinary character; but their vast importance, owing to the additions they will make to the sum of human knowledge, will be an ample recompense." * I mention this, because in some circles the mere vainglory of reaching the North Pole seems to be considered the *acme* of the labours of the brave and accomplished men who are so soon to leave England, just as among the same people to march up a steep mountain, and then like the King of France, in the nursery rhyme, come down again (if possible with greater celerity than they went up), is the aim and end of all alpine research. In all likelihood the "North Pole" will be found to be situated in the midst of some icy sea, or if on land, in the midst of some dreary waste, its position only ascertainable by a long series of observations by the scientific officers, and differing certainly in no degree from the region immediately surrounding it. It is impossible to say what branches of science will be most advanced by the researches of

* "The Threshold of the Unknown Region," 3rd edition, p. 325.

the expedition. Oftentimes discoveries are made when least expected. One discovery leads to another, and with the material at hand an accomplished naturalist can never fail to make interesting observations, and even deduce important generalisations which those at home, only acquainted with what has already been done, cannot even presage. Still there are a few points in various branches of science which it would be well that the naturalists should attend to, and which the Jeremiahs, who are never weary of crying that all is barrenness, should be aware still require solution, or more extended observations in regard to. Let us take geology. Over the North of Europe—most markedly in Great Britain—America, and in all likelihood, Asia also, are found certain remarkable deposits which are believed to date from one of the latest geological epochs, viz., that known as the glacial period, and are known to have been caused by ice. These deposits are very varied, but they may be referred to three great series, viz., great beds of stiff tenacious clay, unfossiliferous, but mixed with rounded boulders most frequently scratched and ice-worn; a series of finely-laminated clays, containing fossils, chiefly Arctic shells; and lastly beds of sand and gravel and boulders, rounded and angular, scattered over the country, and belonging to formations not in the immediate vicinity; indeed often far distant from the localities where these boulders and "travelled blocks" are found, showing that they may have been transported by some agency. This agency is now universally conceded to be ice in some form, most likely icebergs. Ice, again, must have been at work in forming the "glacial beds;" but whether floating ice, or some great ice cap covering the whole country, is as yet undecided, though the preponderance of belief points to the latter as being the mode in which the ice was formed. Agassiz long ago pointed out that Scotland must have been swathed, hill and dale, mountain and valley, in such a great glacier covering. For long he was treated with incredulity, simply because we knew of no country which at the present time was in such a condition,* and therefore, reasoning on the great principles taught by Lyell, we could not accept such a hypothesis. We now know that Greenland is a country in exactly such a condition, and it is to it that we must look for an explanation of the glacial phenomena of Britain and the rest of the Northern hemisphere. The naturalists, by a thorough study of glacial phenomena in that great country of glaciers, can do much to solve the questions now under discus-

* Yet in 1780 Otho Fabricius wrote ("Fauna Groenlandica," p. 4), "interioribus ob plagam glacialem continuam inhabitabilibus;" and Lars Dalager, among others, described the "inland ice."

sion. In this country, and indeed in any country but Greenland, we cannot do so. Take Mr. James Geikie's "Great Ice Age," as the book which most fully—though still not so fully as it might—treats of these questions, and there is work enough for a geologist lying ready at his hand.

What is the nature of the material lying under the great ice cap of Greenland? Is it the counterpart of the Scottish boulder clay or till? Are the finely-laminated clays forming in the Greenland ice fjords from the mud-laden streams which flow out from beneath the glaciers the same as the brick clays of Scotland and elsewhere, as the present writer has shown to be highly probable? Again are the Greenland fjords, as are the fjords in other parts of the world, due to the wearing action of ice, when they formed the beds of great glaciers as Nordens-kjöld and I have argued? Again, the whole question hinges on the theory—not a theory, I believe, but an established fact, but still opinions differ—in regard to the eroding power of ice. In studying ice—sea and land—alone the geologist would be very fully and profitably occupied for a couple of years.

Another question for him to try and solve is this—Is Greenland rising in the North, while we know well that it is sinking in all the region south of Wolstenholme Sound? Are the terraces you find on the shores of Smith's Sound evidences of this general and gradual uprising of the shores going on, or are they only like the terraces you find on the shores of Greenland south of Melville Bay, which we know are evidences of a *former* uprising, not of one now going on, for at the present time I find others have shown* there are indubitable signs that a gradual sinking of the coast is in progress. Mr. James Geikie—a most competent authority on all questions touching glacial deposits—suggests to me that "it would be very interesting to have determined whether the raised beaches of Greenland give any indication of changes of climate such as have been observed in these deposits in Spitzbergen. Great banks of *Mytilus edulis*, *Cyprinà islandica*, and *Littorina littorea*, occur in that island, and none of these species are ever found living in the Spitzbergen sea. It is true that *Mytilus* is occasionally seen attached to algæ in these regions, but such rare birds are but poor representatives of the banks of the same shell which are met with in the same island. Mr. Nathorst, of the Swedish Geological Survey, tells me that in 1870 he examined these shell-banks, and found one made up of *Mytilus* resting upon a scratched rock surface (now far removed from any glacier), and the scratches ran parallel with the fjord. The *Mytilus* still lives in Greenland, as does

* *Physics of Arctic Ice*, "Quart. Journ. Geol. Soc.," vol. xxvii. (1871); Pop. Sc. Rev., August 1871.

also *Cyprina islandica*, but *Littorina littorea* does not. Heer notices these circumstances in his paper *Die Miocene Flora und Fauna Spitzbergens* (Kongl. Svenska Vet. Akad. Forhand. Band 8, No. 7, p. 23). It would be worth while, I think, for the naturalists attached to the Arctic expedition to examine any raised beaches they may come across, with a view to discover whether the facts bear on the conclusions drawn by Swedish geologists, for it is difficult to believe that a considerable change of climate could take place in Spitzbergen without also leaving traces in North Greenland." All these questions are of deep philosophical interest. There is another not less interesting. The vegetation of Greenland now-a-days is meagre enough—no tree, no shrub higher than the knee, and then only in favoured places. But just towards the close of the cretaceous period, and during the miocene age, a luxurious flora of evergreen trees and shrubs, oaks, magnolias, chestnuts, cypresses, red woods (*Sequoia*), ebony, &c., flourished in Spitzbergen, Greenland, the Mackenzie River, and Alaska—in fact forming a circumpolar belt of rich vegetation, some of the species of which also stretched far to the south. The Southern States of America or California affords a vegetation which may be compared with this tertiary flora of the Arctic regions. In West Greenland at the present time it is only found in the vicinity of Disco Bay and the Waigat Strait, not stretching beyond 71°, where it is conjoined with beds of coal, and broken through by trap dykes. No doubt its range was at one time much more extensive, and has been circumscribed by the soft strata being destroyed by disintegration and the wearing action of the ice; for we cannot believe that a flora so extensive in its range could have been limited in Greenland to such a small area. Most likely it at one time stretched right across Greenland, before the country got overlain by ice. It would be interesting to find patches of it in the regions geologically unexplored further in the North. The whole geology of such a region would be extremely interesting. Most likely other formations than what we know of in West Greenland will be found in the North. In East Greenland, for instance, liassic beds, unknown on the west coast, have been discovered on Kuhn Island, and there is a probability that other mesozoic beds—perhaps the true carboniferous strata of Melville Island—may be discovered dotting one or other, or both shores of Smith's Sound, or the Strait, the entrance to which bears that name.

Some people ask, "What is the good of this expedition?" The plain English of such a question is, I suppose, how much money is to be made out of it? Well, we may at once answer that the *Alert* and *Discovery* expedition is not a joint stock company, of which Captain Nares is chairman, and that there will be no

dividends in the form of pelf to the shareholders, viz., the English taxpayers. There will, however, be a richer reward than any money can give, in the advancement of knowledge, the stimulus it will afford to enterprise, the training of our seamen for future work, and the glory which will attach to the English naval name from the gallant deeds which are sure to be done in the far North by the officers and men attached to it. But still, if the expedition was to discover a vein of cryolite—a mineral only found in one spot in Greenland, and of such value that sometimes twelve or thirteen ships will load with it during the summer—in a locality sufficiently accessible, there are plenty of merchants in the city of London who would gladly pay the costs of the expedition for the privilege of working it. In zoology we must not expect too much. The researches of the expedition will be made in a very high northern latitude, where animal life is scarce. Perhaps the very scarcity of it makes the species which live there more interesting. The extreme northern range of animal or vegetable life is always valuable to know; and accordingly every specimen, more especially of the land fauna, will be an important acquisition to science. The sea even, in high northern latitudes, often swarms with the lower forms of life, particularly on banks, and there the zoologist might reap a rich harvest with the dredge. The sea is often thick with the most beautiful forms of acalephæ, none of which can be preserved in a condition fit for identification or description. They must be described and drawn on the spot. A naturalist, skilful with his pencil and sufficiently instructed in the subject to be capable of describing these animals accurately, might alone find sufficient for his labour, as day after day the vessel sails along, is "hooked on" to an ice-field, or lies at anchor. Now-a-days naturalists are not so particular about having a long list of new animals, or rare species. They are more anxious about the range of particular forms of interest, about questions of structure, and other particulars bearing on the philosophical questions of the day. These points can frequently only be made out by dissections on the spot. The large animals will afford plenty of material to the scalpel of the anatomist. What would a home-staying anatomist give, even to dissect on an ice-floe, a narwhal, or a white whale in a fresh or in any condition. He looks back with sadness to Barclay's description of the white whale, the only one we have, and has a tradition that once a narwhal reached Scotland in brine, and was described by an anatomist who has not yet published his descriptions. The northern ranges of the birds, their nesting, their eggs, their changes of plumage, their parasites, and a dozen other points well known to the ornithologist, would give even this unpromising department of

Arctic zoology some interest, and yield results which science will not despise. The fishes of the Arctic seas, as the discoveries of late years have shown, are not "worked out," and the fresh-water species of the North will be of extreme interest. Let us only take one or two points as illustrating what may be yet done in even the higher groups. One might suppose that, after the Danes had lived in Greenland for 150 years, there were not many new mammals to discover in that country. But we have seen, by the discovery within the last few years, of three land mammals previously unknown to the fauna, that this is not the case. Take the musk ox (*Ovibos moschatus*); Fabricius, no doubt, described it under the name of yak (*Bos grunniens*) as a member of the Greenland fauna, but all he saw was a skull drifted in the ice from the high North. The gradual discoveries of Kane, Hayes, and lastly of Hall, have shown that in the very highest reaches of Smith's Sound it is quite abundant, though entirely unknown south of the glaciers of Melville Bay. Almost contemporaneous with this discovery was that of the German expedition to East Greenland, that in a high latitude it was abundant on that coast, though quite unknown further to the south. Take, again, the lemming (*Myodes torquatus*). Scoresby, and afterwards the German expedition, found it on the north-eastern shores of Greenland; but it was quite unknown on the western shores until Dr. Bessells, of Hall's expedition, obtained it from Smith's Sound. Here is a very curious distribution of life, the same animals being found at about the same latitude on both coasts, and yet unknown south of these parallels. The interior, it is believed, is covered with ice. The animals could not have crossed over a stretch of 600 or 700 miles without food. Have they worked their way round the northern end of the continent, and if so, what is the northern termination of Greenland? Is the interior, as is believed by the best informed physical geographers, covered with a great glacier covering? I think the preponderance of facts is in favour of this view, and that the moraine supposed to have been seen on it, near Upernavik, is only local. Further to the south we find no moraine, and if the ice crossed over or infringed on any land in the interior such moraine would be sure to be found in it. Lastly, the ermine (*Mustela erminea*) has been found on the east coast, though this animal is entirely unknown on the west. The habits of few of the Arctic mammals are well known, and any notes on these would be interesting. The European birds—in large numbers and of many species—every summer migrate to the furthest North. For what purposes do they migrate, and where do they all go to? Professor Newton, of Cambridge, has called attention to the strange movements of the knot (*Tringa canutus*), which migrates to Greenland and

Iceland, but it soon leaves these regions and must move further to the north; but where it goes to is unknown, and of its nidification we know nothing. It comes to Britain in large numbers—old and young birds—in the autumn, but again soon takes its flight to the far South until the following spring. Where does it go during the summer? To regions less sterile than Greenland and Iceland—but where in the North are those regions? Is this expedition to discover them surrounding the shores of that open Sea, in the warmer regions which are believed by some to surround the Pole, but which other sceptical souls have long ceased to place any faith in? Perhaps not. Still there is no use denying that "there is a great deal to be said" in favour of "the open Polar Sea."

Dr. Hooker's classical paper on the Arctic Flora* has so fully explained the peculiar condition of the vegetation of Greenland that, if even my space permitted, any explanation of the Phytogeography of that country is unnecessary.

The vegetation—meagre as in all probability it must be—of the far North must be extremely interesting. Already Smith's Sound has yielded additions to the Greenland Phanerogamous plants. There are many puzzling varieties of Arctic plants, epilobiums, drabas, dryas, &c., which it would be well to investigate; and the whole flora should be studied, not from the mere dried-hay point of view, but with reference to its origin and nature, as so lucidly and philosophically explained in the treatise of the President of the Royal Society just mentioned. The cryptogams will yield many novelties; lichens, mosses, algæ, &c., will all be found in abundance. We know little of the Arctic algæ. Disco Bay yielded to the present writer almost as many species as had been previously known from the whole Arctic regions. Botany, however, will not be the branch of natural history which will be most advanced by this expedition. Geology or zoology will be the greatest winners.

I have only taken up these three sciences as specimens of what may be done. Even then I have only touched upon one or two points. Had I more space at my disposal, I could have pointed out a score of other questions still requiring solution, and which this expedition can assist in solving, if not solve altogether.

The other branches of science I have purposely avoided, as being foreign to my studies, and my opinion on them can therefore be of little value. Mr. Markham has given an outline of what additions to our knowledge in these departments we may look for from researches in these fields of knowledge, and to his

* "Trans. Linnean Soc." vol. xxiii. p. 251; "Proc. Roy. Geog. Soc." 1871, &c.

work I refer the reader. For instance, a series of pendulum observations at or near the Pole would be of service in determining the true figure of the earth. The nearest point to the Pole at which the pendulum has been swung for geodetical purposes is 600 miles from that point, and yet Sir Edward Sabine's observations are those which we chiefly rely upon for our knowledge of the earth's figure towards its northern termination. Terrestrial magnetism, and the study of the aurora by spectrum analysis, will yield good results—perhaps entirely new. The meteorology, the temperature of the sea at different depths, the nature of the currents, are all important subjects, and may be advanced by the researches of the officers of this expedition.

Finally, additions to our knowledge of the ethnology of the far North may be advanced by a study of the few remnants of the Eskimo now living in Smith's Sound, by an investigation of their kjokkenmöddings, or refuse heaps and grave mounds,* their wanderings, &c. It may be found, though this is not probable, that detached tribes may be found still higher North than we yet know, and I think it is not improbable that the Eskimo of the east coast of Greenland doubled with the lemming and the musk of the northern extremity of the continent, and then spread to the south. In this case it would be interesting to compare the remains, implements, &c., of Smith's Sound with those of the east coast, brought home by the German expedition, or contained in the Ethnological Museum in Copenhagen.

Elaborate instructions will no doubt be supplied to the naturalists regarding all of these questions.† It is to be hoped that they, like the commander, will not be hampered by too many instructions prepared by naturalists, who, however eminent, may be unaware of the difficulties which a naturalist has to meet with in his researches in such a region. If they are qualified—as doubtless they are—for the duties, then they may be safely left to do what they can. If they are not qualified, then for the credit of English science they had better be left at home. No one, however, who knows the stuff out of which the expedition is composed, will ever hesitate in believing that—though such an expedition is to a great extent at the beck of the ice, and a hundred other circumstances which those who have never sailed the ice-choked seas of the North can have little conception of—every man will do his best; and the best will be very good indeed.

* It has been found that the iron which faces the old bone knives found in the old Eskimo graves in Greenland is meteoric.

† Arctic Committees of the Royal Society and the Royal Geographical Society, at the suggestion of Mr. Markham, are now preparing manuals, giving a summary of our knowledge of Greenland.

ON THE DISPOSAL OF THE DEAD.

By Dr. RICHARDSON, F.R.S.

THE recent discussion on cremation has, for a moment, excited much public interest on the whole subject of disposal of the dead. The subject is one fruitful for discussion, and one that will probably long remain fruitful, not because of the practical difficulties of modes of disposal, but because of the differences of sentiment that prevail, and of the social, and I may say legal objections to that mode which many men of science, dealing only with the scientific side of the question, are inclined to consider as the method most perfect and most advantageous to the physical interests of society.

In studying this subject in a practical point of view, men of science have to take into their consideration the psychological not less than the material side of it. That they will by any force of enactment make any one exclusive method universal is not to be expected. They might as well hope to introduce one religion, or one taste, or one food, or one sentiment, and give to that unit universal rule in communities, the members of which are more sharply divided by psychological differences than by any other causes of division common to mankind.

To bury, to embalm, to cremate, mean in fact three acts the inclination to either of which depends altogether upon the disposition of those who have to carry the acts into practice. This disposition depends not on reasoning, but on instinct. This instinct depends not on accident, but on the most veritable of all human endowments, on the organic origin and build of the man and of the men from whom the man springs; in other words, upon racial and family dispositions or qualities.

It accorded with the disposition of the ancient Greek to burn his dead. For the Greek was the father of mirth, and it was never in his happy mind to retain long near to him that which would hold him in gloom. So to the eternal fire must go the nearest and the dearest when the spirit that animated the body was resolved away. Burial of the dead was to his mind a slow and even wearisome process, to be followed out only in emer-

gency. The traveller who should find a dead body was asked to bury it, or at least three times to cast dust upon it:

> Quanquam festinas, non est mora longa, licebit
> Injecto ter pulvere, curras.

And the sailor who floated ashore from the sea bore on his body the most costly gift he possessed for him who should give its lifeless bearer the rite of burial. But these acts were exceptional, the necessities inflicted upon those who could not be submitted to the pyre.

Beyond this reason, moreover, the Greek found and felt another motive for that system of cremation he all but universally practised. Strange as it might seem to men of other races, the very process of submitting the body to be burned was to him the sign of the life that is immortal. The body he with so much ceremonial committed to the fire was not in his ideal destroyed. Great men, according to that ideal, were to be raised to the world of the higher intelligences; and Pluto himself, because he taught the very art of disposal of the dead, was, for his art, believed to have been received into the number of the gods. No! the thought that animated the Greek was the simple reverse of the material conception of organic structure, living or dead. The men who transformed their heroes into divinities, and who carried out their young dead to the pile before the dawn, that the sun might not be the witness of so terrible a calamity as the cessation of life while yet it had not approached its perfected glory, were hardly the men to be tainted with the belief of the cessation of individual phenomena with the cessation of that visible motion from which we infer that the body that once was living has ceased to live. With the Greek, the burning, to which he subjected the dead body, was a process for the purification of the soul. The soul, left unclean in its earthly state, required to be rendered quite perfect by the absolute purification even of the casement in which it had been enshrined during its mortal course, and to which it must still cling. So they submitted the casement to the *pur*, the great and absolute purifier, the fire. Further, they conceived that in this purification they set free the indestructible principle of life, that it might enter the more speedily into the domains of the blessed. This was the Greek ideal of what we call cremation. Symbolised, somewhat differently, it remains to this day connected with a faith to which millions pay allegiance.

It accorded with the disposition of the ancient Egyptian to retain his dead as perfectly as art could enable him. The body, the receptacle of the soul, was too precious to be cast away to the earth to rot there, or to the sea to be devoured of animals,

or to the fire to be resolved into thin air. It was to be held so that the spirit which once animated it might at some strange and eventful moment re-enter its tabernacle and reign in it again, incorruptible. In this ideal we have the origin of a belief which is still most prominent in the thoughts of mankind: a root of a faith symbolised specially, and accepted also by millions of men. In our care of burial of the dead, in our sepulchres and stately tombs, we strive to express what the heart prompts from this source. The ideal received its fullest recognition in the process of disposal of the dead by embalming. The poorest and the richest Egyptian preserved his dead, in this hope, with all the perfection his means could devise. The rich man with his costly gifts left his lifeless friend in the hands of the embalmer for seventy days, and received back the body swathed in cloth and gum, so perfectly prepared, that set up amongst the living or laid in the sarcophagus of all but solid stone, it could be left safe there for all the ages that were to come; left, not dead, but waiting in solemn silence for the renewal of life that would one day as surely revive it as the sun revives the silent earth into the living day.

When father Abraham, refusing the gift, bought of Ephron the Hittite for four hundred shekels of silver the field before Mamre, that he might bury his dead out of his sight in the cave of Machpelah, he followed another disposal of the dead which, through all the variations of the marvellous race he founded, has held its course. To the Greek this mere burial were barbarous; to the Egyptian a poor imitation of that perpetuation of mortality by which the mortal would be made to rejoin the immortal part. Yet again it symbolised, in another way, the same ideal. The seed sown in the ground is buried, but does it not spring up again? That which is sown is not quickened unless it die. And so with the body: it is sown in corruption, it is raised in incorruption: it is sown a natural, it is raised a spiritual body. How fixedly this principle of burying in the earth, of returning to the earth that which came from it, has remained rooted in the minds of men, through Jewish interpretation, let any thinking person consider. The masses cling to it despite pictures of disgust, however realistic; and even the choicest of our philosophers have held by it to their final sleep, and have written of it themselves.

"The body of Benjamin Franklin, printer, (like the cover of an old book, its contents torn out and stripped of its lettering and gilding) lies here food for worms. Yet the work itself shall not be lost, for it will (as he believed) appear once more in a new and more beautiful edition, corrected and amended by the Author."

In these later days the disposal of the dead has been consi-

dered more purely as a scientific question. It has come scientifically into notice in connection with the work of sanitary advancement, and upon this basis it has been discussed with much activity. Growing out of the discussion has arisen an effort to introduce into our country the ancient Greek and later Roman method of cremation, but without reference to that sentiment by which the cultivated Greek made the process a solemnity and a hope. It is the design of our modern cremation to accomplish a destruction, not to institute a rite: to get rid as quickly as possible of an offensive and objectionable mass of organic putridity, not to consign for perpetuity the unmatchable mechanism of life, in its design indestructible, that it may exist again.

In this proposal of modern times there is a return to a philosophy of a Roman school which once had many followers; but which, failing to appeal to the heart of man, fell before the gentler and sympathetic part of the mental organisation. I believe it will fall so again and again, unless in the course of nature the two nervous lives with which we are endowed should be organically remodelled, and the reasoning parts gain the pre-eminence, the head overcome the heart. But then the passions will one and all be lost, and the cold reasoning being —he will be no longer an animal—that will remain will have no sentiments and therefore no sympathies; no uncertainties, therefore no hopes; no hates, therefore no loves; and no gratifications except those that are infinite and away from the common sphere in which he is doomed to breathe his purely physical life. There is little indication up to the present moment of any such radical reorganisation of man as this, and we need not expect the cremationists much chance in our generation. Indeed they are out-voted a hundred to one by the extreme sentimentalists, who would still embalm their dead and retain near them even the silent form of that which, after it became silent, was felt to be beyond all previous conception beloved and precious. I have myself seen many instances of embalmment; I believe there is no mode of disposal of the dead that is so tranquillising and solacing, at the moment, to the living; and I am far more prepared to see the advancement of this mode of disposal of the dead than of that by the sharp and decisive fire.

The probabilities are that, on the whole, matters will long remain much as they exist at the present moment. The majority will hold by the present system of simple interment in the earth; a minority will follow the process of embalming; a smaller minority will support cremation. Putting aside all feeling in the matter, it may be useful to consider what disadvantages or advantages pertain to each method.

The advantages urged against simple burial in the earth are, (*a*) that such mode of burial is injurious to the living; (*b*) that the earth becomes impregnated with the remains of the dead, and that sometimes the very water which filtrates through such earth becomes the drinking-water of communities; (*c*) that from the graveyards there arise offensive gaseous emanations which, breathed by the living, are sources of disease; (*d*) that old burial-places, if they become unearthed, are possible sources of contagion; that the contagious matter buried with the dead who have died of pestilence, though remaining harmless while stored up in the earth, may, if set free by the removal of the earth, be disseminated amongst the living to distribute once more the poisons of the spreading disease; (*e*) that the thought of the dead undergoing slow decomposition in the earth during long periods of time is, when it is brought before the mind so as to be fully realised, of all thoughts most repugnant and terrible.

If all these charges against the ordinary mode of burial were really true and unavoidable, little could be said in its favour. It really happens that none of them are necessarily true. It may be that in some instances too close proximity of the home of the dead to the home of the living has been hurtful. I was once consulted on the subject of the supply of water to a town in which an impure supply was derived because it had filtered through an old burial ground. But the error was soon amended, as others might be with equal ease when they occur. The objection against the emanations from graveyards is equally removable. By a bad social arrangement, by placing a graveyard in the midst of a crowded population, and by super-filling it with dead, much harm may and possibly has been done; but there is no need for any such an outrage; no more need than for piling up combustible matter in the heart of a town or city. To remove the dead a distance of even a mile from the living, and to bury them properly, in sufficient space, is in truth all that the most rigid sanitarian can reasonably desire. Who in our large cemeteries or in our village burying-grounds, where proper order and decency prevail, ever found the existence of a dangerous emanation from the dead? What evidence is there anywhere of one single instance of a contagious or epidemic disease derived from such a source? On the contrary, the entire absence of propagation of contagious disease from the cemeteries of such a city as London, is the best and surest proof that the system of burial in the earth is unexceptionable as a means for the final burial of contagion.

The statement that the poisons of the contagious diseases have been set at liberty by the reopening of old burial-grounds

and the removal of the contents of these grounds, though it has often been made, is one of those arguments that would require a great deal of new fact before it could be accepted as reliable. In our time, certainly, no fair instance of this evil has been revealed in our country; nor is there the remotest reason to assume that the organic poisons of the spreading diseases are so indestructible that they will remain undecomposed while the other organic parts resolve into gaseous products of decomposition.

Indeed, except by direct inoculation from it, it does not appear, in evidence, that even the recent dead body, dead of a contagious malady, is capable of communicating contagion to the living. The motion of life is necessary for the poisonous particle to be disseminated that it may light disease. The dead body, like a candle that has been perfectly extinguished and then ceases to give forth the light which, before it was extinguished, it could so readily communicate to other bodies that are capable of burning, is harmless when it has ceased to glow. And so, when we carefully investigate this question, the danger arising from the dead who have died of contagious maladies, we find amongst those who are engaged in moving such dead for burial—the undertakers and their assistants—no instance of the origin of any contagious malady as a consequence of the exercise of their particular calling. On this ground of assumed danger from burial there is in fact no necessary case.

The last objection to the mode of disposal of the dead by burial in the earth, though it seems at first the most cogent, is practically unreal. It is so natural an act to bury what is dead, that the thought of the after changes to which the buried body is subjected never troubles the minds of those who live. There is something about it that cannot enter into the mind to terrify it. Claudius himself, with death in his face, though he thinks it terrible "to lie in cold obstruction and to rot," "his sensible warm motion to became a kneaded clod," shrinks less from this apprehension than from that of the delighted spirit bathing in fiery floods or residing in thrilling regions of thick-ribbed ice, or a worse than worst, to be with those that "lawless and uncertain thoughts imagine howling." The same with the few of his class. The majority, like Diogenes, rather than Claudius, think nothing of the disposal of their inanimate bodies. What matters it, "nihil sentienti"? For the like reason those who live to bury their dead have no sense of after disgust in the fact. They go to the grave, plant it with flowers, or cover it with the monumental stone, and speak and think of the sleeper beneath with no sentiments save those of love and sorrow, and the reason of this is that they are at one with nature. The earth calls for the dead, that she may bring

forth the living. What changes she effects in the intervals of change are so perfect and so concealed that had she entirely her own way there were no more discernible offence in burying a man than in planting a seed. What evils arise are due to the ceremonial we follow of partitioning the body from the earth in slowly-destructible investments of wood or of metal.

The advantages of burial in the earth, when the process is correctly carried out, are, that of all methods it is most economical and most simple. That it admits of being made a perfect protection to the living; that it carries with it nothing that is repugnant to the mind at the time of disposal, and that in the economy of nature it allows her to have back the rich nitrogenous compound ammonia from which to reorganise the lower vegetable existences for the use of the higher forms of life which we call animal. On these grounds of absolute necessity the natural position is so strong, that we do not believe any human argument against it, however plausible it be, will prevail. To suppose so much is to admit that men may be at successful variance with the design of the universe, and still progress. The splendid allegory of the inferior spirits warring against their master and designing new plans of government in heaven and on earth, teaches that this idea of revising the natural ordinances is a conception doomed to fail by whomsoever tried.

The disadvantages connected with the disposal of the body by the process of cremation are varied. In the first place, that the process should be safe it must be very perfect. To consume the dead body by fire slowly and by imperfect combustion would be but to create a veritable nuisance and a real danger, to say nothing of the disgust that would be excited by such procedure. To make the combustion perfect, a furnace of a special character must be employed in which, with the most rapid combustion, a period of one hour is required to reduce the adult body to ashes. Presuming the principle of cremation by this perfect method to be established, it remains doubtful whether, as a matter of economy, it would ever become universally applicable in large populations.

Another objection has been well raised by Dr. Mohr, based on the question of the natural economy. In the perfect destruction of the animal by fire, Mohr shows that the tissues would be resolved into the elementary gases, and that no intermediate product of ammonia would be yielded. Thus this most indispensable product of nature, ammonia, would be lost so far to the vegetable world, and one of the grand designs of nature would be impaired. It were vain to say that this loss means little. It might mean little if cremation were to be in-

stituted only as a fancy process, in which the few who considered it a costly luxury might indulge. But applied to all the dead, it would in the course of ages become a direct robbery from the resources of the planet—a robbery as great, to use the illustration of Dr. Mohr, as that of the coal-fields which is now so extravagantly in progress.

There is yet another objection to the process of cremation, which, hard and painful as it is, must still be admitted. The objection is, that the method of complete destruction by fire would conceal many cases of death from modes of death that are not lawful. On this point all who are best acquainted with the details of medical jurisprudence are unanimous. They tell us that, even under the system of burial in the earth, some murderers, who silently ply their awful crimes, skilfully escape justice. Give then to these criminals more advantage, let them know that evidence of their infamous work may be absolutely removed if they can only convey their victims legitimately to the furnace, and they will be emboldened beyond all measure that has heretofore existed. To meet this objection, which no one doubts is valid, it has been suggested that in doubtful cases portions of the viscera should be retained—should not, that is to say, pass into the fire. If this were done, however, it would only meet a part of the requirement of the analyst who, when once his analytical work commences, may demand for its completion the whole of the soft tissues of the body; neither would it meet a much more important requirement, viz. that the body be not too hastily destroyed. In all the instances where an order for exhumation of the dead has gone forth, and these are the very cases now under consideration, the suspected murderer has so skilfully evaded suspicion that he has succeeded in consigning the body to the earth. What then if, instead of the earth, we were to let him consign it to the fire? Could we by any known device give a better means of escape from detection? The medico-legal authorities are not wrong in this view which they take of the extreme danger of cremation. They know already too many instances in which, even with the protection afforded by retention of the bodies of the dead in the preserving earth, the law has failed to seize the guilty hands that laid the bodies there, to be sanguine in favour of a process of disposal of the dead that shall act as a further temptation to the wicked for deeds of secret murder.

The advantages claimed for cremation are that it is a sound sanitary protection; that it removes instantly the decomposing mass of the lifeless and useless body; that it is less objectionable to the mind than the process of burial; and that its adoption, by doing away with that reverence—it may be said superstitious reverence for the dead which now exists—would

remove from our sight the costly pageantries of burial which disgrace our civilisation. On all these points of argument, barring the first, sentiment rather than science prevails. In respect to the first or sanitary part, science teaches that burial may be made as protective of the living as cremation, and with that expression of fact, the only fact before us, I leave this part of the subject.

The disadvantages of disposal of the dead by embalmment are many. To embalm a few bodies only, and thus to make the process what may be termed a luxury, can do no injury to the community; but if the process were extended, and the surface of the earth were transformed into a standing-place for the dead as well as the living, the inconvenience would soon be felt beyond endurance, and the economy of nature would be disturbed as effectively as if the masses of body were dispersed in gaseous products from the fire.

Embalming has, however, in these days been brought to such perfection that it may, when required, be effected without danger to anyone except to the operator. It is performed rapidly by the process of injection of a preserving fluid into the arteries of the dead body. This solution consists of chloride of zinc dissolved in water; and when the process is effectively carried out, the body is left with all its tissues solidified, so that it is nearly as solid as stone itself.

In the case of persons who die far from their home, and whose friends wish to have them retained unburied until they can be interred in the same burial-ground with other members of the family, the feeling which dictates embalming is fairly gratified. In the case of unknown persons who are found dead, and around whose deaths some doubts hang which nothing but identity can solve, the feeling which dictates the preservation of the body may be sanctioned by the requirements of public justice. But when the desire for embalmment is meant only to gratify a morbid craving on the part of a few living persons to retain the mere animal remains of the dead, then the conditions are changed, and the only circumstances that can justify the demand fully are those which relate to history. It may be urged that great historical personages may be embalmed with advantage; it may be urged that persons who are not in any sense great, but who from some peculiarity of physical construction are of interest to the natural historian, may be embalmed with advantage. Here I think the argument in favour of embalmment rightfully ends.

Thus in respect to the general question of the disposal of the dead, the common sentiment, and, as I think, the common

sense, is with those who adhere to the ancient practice of burial in the earth. But in stating this it is proper to admit that many important improvements are required in the process of modern burial.

I omit all mention of such improvements as are required in mere matters of ceremonial. No argument of science will influence men and women on that particular. If cremation or embalmment, or any other mode of disposal of the dead, were to become the current fashion, the external or ceremonial additions might remain, practically, as extravagant as ever.

Imprimis, I believe it to be entirely unnecessary to remove our cemeteries long distances from towns and cities. The present arrangements, such as have been carried out during the past twenty years, have so far, I believe, met every necessity, and a judicious extension of the existing system is probably as good as can reasonably be followed.

The only source of contamination that can come to the living from the dead consists in the possible danger of having for a town a water supply drained from springs which in their course pass through the homes of the dead. But that such a necessity ever exists is fairly open to doubt. In few places, I presume, need the dead be buried at a level above the source of the water supply, and when in any given place where, from the water supply being from wells only, the cemetery must be above the water, the distance at which it is placed from the wells may always be sufficient to prevent contamination. Water containing organic decomposing matter cannot percolate many yards through a good carboniferous soil without being rendered innocuous. It is from this circumstance that, in the midst of many errors as to mode of burial in past times, the occurrence of disease from this source of water contamination has been so rare.

The modern improvements really required in burial are of four kinds. They relate:

Firstly, to the construction of the soil of the cemetery.

Secondly, to the mode in which the dead should be placed in the earth.

Thirdly, to the superstructure of the soil of the cemetery and the vegetation.

Fourthly, to the method in which monuments to the dead should ultimately be set up and preserved.

The construction of the soil of the burial-ground is of first moment, and might readily be made matter of legislation. The soil that is most fitting for this purpose is a fine carboniferous mould or a mixture of carbon, lime, and sand. In such a soil the complete removal of the body might, under proper conditions of burial, be secured within a period of ten years, and in such a soil renewal of burial might be safely carried out after every

such interval. In Naples it has been customary to bury in pits of earth with which lime has been mixed; to bury so many bodies in one section on a given day, to allow that section to rest for a year, then to remove the whole of the earth of the section with its organic remains, to refill with new earth and bury again for the next year in the new earth. In this country such a prompt system would not be tolerated; but the method of burial in a destructive, but more slowly destructive, bed would meet probably every view, without creating undue prejudice at the commencement of the reformation. In some localities a natural soil would yield all that is wanted for a perfect burial in earth. In other localities the earth would have to be specially constructed, and a series of carefully conducted experiments on the destructive powers of various earths are required before a perfect system can be evolved. It will probably be found, I repeat, that an earth composed of equal parts of fine carbon soil, sand and lime would be the most rapid of all combinations for the destruction of the animal matter with absorption of the products of decomposition. In a cemetery correctly constructed with twelve feet of prepared earth as its basis, such soil might remain undisturbed, except for purposes of burial, for many years. Long enough, certainly, for the burial-place of the majority of the dead to be forgotten and for the dead body to pass into entire reunion with the earth from whence it sprang. After a given and due time, without any injury to sentiment, the soil could be removed in sections, and be resupplied with new material for new burials.

I have described the artificial soil which would prove the most effective for the purposes of burial from the facts I have gleaned during direct observation of the action of different substances on dead organic matter. Specimens of such matter buried in pure carbon, in virgin carboniferous earth, in a mixture of carboniferous earth and sand, and in this latter mixture to which lime had been added, were found to undergo resolution, in the last most effectively, in the first the least. A fresh carboniferous earth answers exceedingly well, far better than simple vegetable carbon. The rapidity with which it deodorizes even decomposing animal matter is most remarkable. It may be said to act in a matter of minutes. The rapidity with which it produces destruction of the organic substance, especially if it be kept dry, is equally surprising. The complete decomposition may be included in from twenty to thirty weeks.

It is worthy of remark, however, that all the parts of an animal body are not equally destroyed. The integumentary parts and the membranes are much more slowly destroyed than the muscular, and the muscular are more slowly destroyed than the nervous. The bony parts are more resistant to destruction

than the integuments, and the pigments are more resistant than bone.

It is not assumed that the abovenamed description of a prepared earth for the cemetery is perfect. It is an approximation to the truth. A carefully conducted series of new experiments are required to bring out the precise facts.

With these modifications of the earth in which the dead should be laid must come an entirely new system of burial. It would be in vain to construct the best burial-ground if the present system of enclosing the dead in coffins of wood or iron or lead were to continue. The coffin should be nothing more than an easily destructible shroud, in which the mortal remains may be concealed from view until they are deposited in the earth. The present coffin is after the mode of an Egyptian sarcophagus, and is probably an imitation of that receptacle. In the form of this receptacle there is nothing objectionable, and if the popular taste wills that it shall be maintained, so be it. But the structure must be so modified that the instant the body is placed in the earth it shall either be in direct contact with the surrounding earthy matter or shall be separated from it by some simple organic material that is easily and rapidly destroyed. The newly proposed wicker coffins would probably answer the purpose intended, fairly; but they have the fault of not being sufficiently destructible. A return to the ancient bier and to the primitive mode of simply enveloping the body in cloth would be by far the most rational modification.

It is presumed by some who advocate this direct mode of burial that interment should in all cases be carried out within a short interval after death; that a period of not less than thirty-six hours should be allowed to elapse between the cessation of life and the disposal of the lifeless body in the ground. There can be no doubt that the method of placing the body in the coffin, and of temporarily closing the coffin, has led to much error in the manner of detaining the dead amongst the living, and it is not less doubtful that when, in any instance, actual decomposition of the tissues has commenced, the time for interment, however short it may be, has fairly arrived. The system of burying without the coffin would therefore in a sanitary point of view be of advantage. It would lead to interment, in every case, so soon as the direct evidence of decomposition had set in, and in the majority of instances that would be within forty-eight hours from the hour of the demise. Third-day burials would become the rule. This period would be sufficient to establish the fact of death on the one hand, and to prevent injury to the living on the other.

Under a perfect system of burial, with the method suggested of removal of the earth and resupply of new earth at fixed and

limited periods of time, there would be demanded a modification of the present plan of planting the surface of the cemetery with trees and evergreens. To surround the place with trees not too thickly planted, to plant small and handsome trees in different parts of the ground by the side-walks and in odd spots where the earth remains undisturbed would be unobjectionable. The rugged elms and yew-tree's shade might still encircle the homes of the dead; but inasmuch as the earth in which the burials are made is to be a moveable earth, it would be impossible, except in particular instances—of which a word must yet be spoken—to plant over any one body any special and lasting tree or shrub. The ground levelled at once after burial should be covered with rapidly-growing vegetation, such quick-growing grasses which can be mown and utilized either as food for the laborious animals or as manure for other land. Thus the products of decomposition from the dead, which by diffusion would find their way to the surface, would be removed by their transformation into new forms of matter as rapidly as they were evolved and distributed.

The last modification, under a new and more perfect system of burial, relates to the records of the dead: the tablets and tombs and tombstones which affectionate relatives place over those they love. How transitory these records are can hardly be accredited until, with watchful intent, the unprejudiced observer seeks for the truth. In scanning our country churchyards it is the rarest thing in the world to find a perfectly legible tombstone erected over a grave of one hundred years. Numbers are either illegible or fail to mark the precise place of burial at twenty years, and few are tended or preserved over five to ten years.

Practically, in fact, the monumental system of record is fast going out, and under a new and better system it would have to pass away altogether. The tablet might remain in a central temple without the cemetery. It might record that within the precincts the body buried there was on a certain day committed to the dust. The inscriptive description of the dead might, as usual, be rendered, and the tablet, being under shelter, would be advantageously placed for endurance. Beyond this the monumental brass or stone could not go. To place it over the body of the entombed, or at the head or at the foot of the dead, as a permanency, would be destructive to the whole scheme of perfect burial. Over the dead nothing more must be placed than a simple mark, which at the close of the term, when the earth is removed and replaced, would also be removed and destroyed. The body is no longer there; it has passed into new forms of matter; the stone therefore, if it remained telling that the body was still there, would be a mere cheat.

It might as well lie on the highest mountain or in the lowest depth of the sea.

Still for the wealthy, for those who can afford to make grief a long luxury, there might remain means of an exceptional kind for monumental sepulture. If in a cemetery a portion of ground were exclusively bought to hold a limited number of dead, such a special grave might be constructed as should remain unmoved. Within a well-built brick vault, filled with prepared earth, and closed by an arch above it, so that water could not enter, the dead could be buried with perfect safety, and might remain so long as the land was in the possession of the family that bought it. On such special ground might be laid the monumental slab, as at present, and here might dust commingle with dust, without any diffusion from the charmed spot until Time the destroyer fought out his invaded rights. Here, too, might be buried, in the sarcophagus or metal tomb, the embalmed dead for the historian to find and depict when Time shall have conquered and won back his privileges. But these exceptional advantages and preservations and reservations of nature are for the rich and sentimental, who make a great part of history if they do nothing else, and who ought therefore to be gratified. The masses who expend all their bodily powers in toiling while they live must expend even when they are dead, and never cease to expend until they cease to be. And that is a period I, for one, wot nothing of.

REVIEWS.

INSECTS AND FLOWERS: THEIR MUTUAL RELATIONS.*

TO be at once Vice-Chancellor of the University of London, Member of Parliament, and a leader among the many financial authorities of that centre of financial speculation, Lombard Street, is no mean feat; for assuredly any one of these positions would satisfy the ambition of most men. But when, in addition to these manifold distinctions, are cited the Fellowship of the Royal Society, and the authorship of some of the most important papers and works on ethnography and biology, we know of but one man in the long list of naturalists who can lay claim to the position. And that man is Sir John Lubbock, the author of the excellent little work that is now under notice. In this book the author has given, in part from his own observation, but principally from Darwin's and F. Müller's able researches, a tolerably complete account, so far as we yet know, of the different contrivances by which insects are enabled to fertilize plants. He has only taken the flowering species in hand in the present work, but he has dealt with them fully, and has given his descriptions in such admirably terse and clear English, that almost any person, be he scientific or not, can follow his remarks. First of all he gives an account in brief terms of Mr. Darwin's results, and shows how essential to plants is cross-fertilization, and in connection with the necessity for insect action in the work of pollen-removing he cites a remark of some interest from some of Mr. Darwin's writings, viz. that it is "an invariable rule that when a flower is fertilized by the wind it never has a gaily-coloured corolla," of which we have numerous examples in the conifers, birches, poplars, and grasses. Then he passes on to the consideration of the structure of the insects' mouth-parts and limbs, to show how they are employed in fertilization; and here he makes the following interesting observations: "That bees are attracted by and can distinguish colours was no doubt a just inference from the observations on their relation to flowers, but I am not cognisant of any direct evidence on the subject. I thought it therefore worth while to make some experiments, and a selection from them will be recorded in the forthcoming volume of the 'Journal of the Linnean Society.' I placed slips of glass with honey on paper of various colours, accustoming different bees to visit special colours, and when they had made

* "On British Wild Flowers, considered in Relation to Insects." By Sir John Lubbock, Bart., F.R.S., M.P., Vice-Chancellor of the University of London. London: Macmillan, 1875.

a few visits to honey on paper of a particular colour, I found that if the papers were transposed the bees followed the colour."

Full of interest as these facts are, they are followed by others not less surprising. Take the case of the female humble-bee recorded by H. Müller. He says: "She made several vain attempts to suck the honey (from an Aquilegia); but after a while, having apparently satisfied herself that she was unable to do so, bit a hole through the corolla. Having thus secured the honey, she visited several other flowers, biting holes through them, without making any attempt to suck them first, conscious apparently that she was unable to do so." And this was not only a single instance, for Herr Müller has recorded several similar cases. Especially interesting are the author's observations on the object of peculiar bands of colour on certain flowers. Sprengel, eighty years ago, referred in his splendid work, "Das entdeckte Geheimniss der Natur," to this subject, and intimated that in all probability those lines had reference to the position of the honey. And this has been borne out by Sir J. Lubbock's inquiries, for he found that bees regularly depend on these lines as guides to the position of honey. For he observes, "I did not realise the importance of these guiding marks until, by experiments on bees, I saw how much time they lose, if honey which is put out for them is moved even slightly from its usual place." It would be impossible to follow the author through all the natural orders, which he deals with as fully as there are materials in each group. But we may quote a few observations which appear to us of considerable importance. And firstly of the process of fertilization in the Berberis, which is so well known because of the singular manner in which its stamens move when they are touched. We assume that our readers are acquainted with the flowers of this by no means rare plant, in which the cross-fertilization is brought about by a curious contrivance. "The bases of the stamens are highly irritable, and when an insect touches them the stamens spring forward and strike the insect. The effect of this is not only to shed the pollen over the insect, but also in some cases to startle it and drive it away, so that it carries the pollen thus acquired to another flower." The question of whether it is natural for plants to be impregnated with their own pollen has been gone into with much minuteness by Mr. Darwin, and he has arrived at the conclusion, as we have already stated, that it is not the proper process. Sir J. Lubbock says that, by a series of careful and elaborate experiments, Mr. Darwin has shown that the well-known flax plant (*Linum*) "is almost entirely sterile, with pollen of its own form. He repeatedly placed pollen of long-styled flowers on the stigmas of the same kind, and pollen of short-styled flowers on stigmas of short-styled flowers, but without effect; while if pollen of a long-styled flower is placed on a short-styled stigma, or *vice versâ*, abundance of seed is produced." Mr. Darwin has proved the same thing in the case of *Lythrum salicaria*, in which plant he finds that there are three descriptions of flowers which he calls the *long-styled*, *mid-styled*, and the *short-styled*; and not only do the styles differ, but the seeds, the size of the pollen-grains, and the colour of the filaments of the stamens. In this plant Sir J. Lubbock says Mr. Darwin has also proved by experiment "that this species does not set its seeds if the visits of insects are prevented; in a state of nature, however, the plant is much frequented by bees, humble-bees, and flies, which always alight on the upper side of the flowers, on the stamens and pistil. Mr.

Darwin has shown that perfect fertility can only be obtained by fertilizing each form with pollen from pistils (*stamens?*) of the corresponding length."

All through the work is full of matter of absorbing interest; and it is abundantly illustrated and exceedingly well printed—two matters by no means of unimportance. We can only say, in concluding this imperfect notice, that we have very seldom taken up a book that we have read through with so much pleasure, and indeed so much profit, as Sir J. Lubbock's "British Wild Flowers."

NUMBER, AN ARGUMENT FOR A GOD.*

ADMIRABLE as were the arguments adopted in the several "Bridgewater Treatises," and popular though they were at the period of their publication, there can, we think, be little doubt that few among the eminent scientific thinkers of the present period put much faith in them. And yet in the little work which is now before us, an eminent churchman, with the best possible intentions, and with a considerable amount of fairness, goes once more over the same ground, and fancies that he proves most conclusively the existence of a God on the old and exploded principle of evidence of design. Indeed, we are somewhat surprised to find one who is eminent in his church leaving aside the subjects on which he doubtless could do much that is good, to wander out, and go so hopelessly astray, in the very wide and almost boundless fields of scientific speculation. Be it distinctly understood that we do not enter on the question, Is there a God? We think such a subject one unfitted for the pages of a journal like this. And what we wish to observe is, the fact that Mr. Girdlestone's argument is an utterly fallacious one, though to many minds it will be doubtless conclusive. But let us ask him, How could you have anything else than order and regularity in the exercise of those laws which govern the world? Let us now suppose, for the sake of argument, that there has been no Creator. How could any law which did not work in the most perfect harmony with every other law have any existence? We may suppose it possible that at one period of the world's history some law may have existed, for a short time indeed!! which was wholly at variance with its fellows. But surely here would occur an example of Mr. Darwin's well-known rule, "the survival of the fittest." Clearly it could but exist for a very momentary period indeed. And yet the writer thinks the facts of number an argument for a Deity. How shallow is such argumentation. How could the world go on if there were a series of laws which conflicted one with the other? Of course the battle would ensue between the adverse laws, and the weaker one must cease to exist. If Mr. Girdlestone was more of a student of Nature, and less of antique works on biological philosophy, we should not have had the present essay for review.

* "Number, a Link between Divine Intelligence and Human; an Argument." By Charles Girdlestone, M.A., Rector of Kingswinford, Staffordshire. London: Longmans, 1875.

GEOLOGIC LAWS.*

WE do not doubt that Professor Von Cotta has given a capital account of the development-law of the earth in his "Geologie der Gegenwart", but we think the translator has failed in his efforts to put the matter before the English public. We are certainly far behind the French in lucidity of expression, but we are infinitely before the Germans in that particular, and therefore a translation should be something more than a literal rendering of the peculiar phrases of the original tongue. Yet the present work is hardly anything more than such a verbatim translation, and is in fact a work more difficult to read than the original. The person who translated the "Wie Gehen sie" into "How go they?" would doubtless have nothing to blame himself in the sense of literalness of rendering; but he surely would not be commended as a translator. And though we do not assume for a moment that Mr. Noel has gone so far as this, we simply urge it as an example. Take the following sentences, for instance: "In the organic realm, summation of results has not only given new single forms, agreeing with the ever-increasing manifoldness in the conditions of their existence, but also, in some of them, an ascending organisation." Again: "Even atmospheric currents, and with these *climatical* circumstances, are also partially thereby conditioned." And, "It is plain that in this way manifoldness of formation was exceedingly increased, and to a certain extent likewise summation applies to the results of these processes." These sentences prove how incompetent was the writer for the task he took in hand. Of the little book itself we have nothing but commendation to offer. It is a thoughtful sketch of the history of the globe, from the time when its materials first gave up their nebulous form to its condition at the present day.

SCIENTIFIC AND GENERAL ESSAYS.†

SIR HENRY HOLLAND was a man of whom the profession to which he belonged—that of medicine—must feel a conscious pride. And this not only for the curative ability which he undoubtedly possessed, but for the manner in which he departed from mere medical pursuits and endeavoured, by a series of travels over almost every part of the civilised globe, to take in all that science, in the widest sense of the word, was attempting to do. And in saying this we are giving him, even when in his prime, the highest praise that it is possible to urge in his behalf. On the other hand, we must with equal force admit that he owed a great deal of his success as a thinker to the people among whom he lived and moved in society. And it must be confessed that even as a thinker he was far from being

* "The Development-law of the Earth." By Professor B. Von Cotta. Translated by R. R. Noel. Williams & Norgate, 1875.

† "Fragmentary Papers on Science and other Subjects." By the late Sir Henry Holland, Bart. Edited by his Son, the Rev. F. J. Holland. London: Longmans, 1875.

original; and that he by no means went further than a certain fashionable circle do at present, who, knowing that a few undeniably great men hold opinions that are Atheistic, go with them to a limited extent. In a word, Sir Henry Holland was a well-informed, polished man, and above all things, he was a man of the world. But it must from the outset be clearly understood that he was no thinker. In the days of Galileo he would, we doubt not, have been on the persecuting side. Then, as to this volume before us, what is our opinion of it? We must say unhesitatingly most unfavourable. Had we indeed no better sample of what the author was able to produce, our verdict would have been that he was shallow, though well-informed; and we cannot conceive anything but a son's pride in his father's work, that could justify its publication. We see in it indications of the mental deterioration of the author; and we cannot conceive anyone save a relative—whose natural sympathy would exceed his reason—consenting to the issue of the book. We have only read some seven of the essays the volume contains, but these were papers on subjects requiring a power of condensed thought for their just development. And what have we found? Why the merest shadow of mental power. A sort of butterfly-like flickering around the solid flame of clear reasoning force, and an inability to grasp powerfully the questions stumbled over often enough. Yet in all these papers—even in his last contribution to literature, which appears in its naturally unfinished state in the preface written by his son—there is a vast mastery of style, which he possessed to the last. And of this it is difficult to speak or write too highly; it is characterised by clearness and forcibleness to an extreme; and for that reason alone these his last essays are pleasant reading. But as any addition to philosophy they are indeed barren in the most extreme degree.

PALÆONTOLOGY OF VICTORIA.*

THIS is the first of a series of publications of the fossil organic remains of Victoria, prepared by the able and indefatigable palæontologist, Professor McCoy, corresponding in plan with the decades of the geological surveys of England, Canada and India, and will contain figures and descriptions of the more characteristic fossils of each formation found in the colony. The present number contains notices of some species of graptolites, which are interesting, not only as proving that the gold-bearing reefs of Victoria are of lower silurian age, but that many of the forms are identical with species occurring in the lower silurian rocks of the British Islands and United States of America, thus showing their world-wide distribution in the old geological time; even the Romans obtained their gold from quartz veins in slates at Gogofau, North Wales, of the same geological age as the Australian formation. Three plates illustrate an extinct

* "Prodromus of the Palæontology of Victoria: or, Figures and Descriptions of Victorian Organic Remains. Decade I." By Frederick McCoy, F.G.S. Melbourne: 1874.

fossil wombat, from the pliocene gold drift of Dunolly, closely related to the *Phascolomys Mitchelli Ow.* from the Wellington caves in New South Wales. Professor McCoy considers these gold drifts are not alluvial, but of the more ancient pliocene tertiary period, at least as old as the mammaliferous crag, and corresponding in age with the gold drifts of the Ural. Whatever may be the age of the Australian drifts, we should take exception to the Ural gold drifts being placed in the crag period, and rather refer them to a later geological age. For, as remarked by Sir R. Murchison, the Uralian detritus contains in many places remains of the same extinct fossil quadrupeds as are found in the coarse gravel of Western Europe. The mammoth, *Bos aurochs*, *Rhinoceros tichorinus*, and many other mammalia were unquestionably contemporaneous denizens of Europe and Asia. As respects Siberia, they appear to have been exterminated, if not simultaneously, at least previously to the existing conditions of the earth's surface in the northern hemisphere, the *Bos aurochs* being the only one of these huge animals which, as far as we know, has been preserved to our days. Species of volutidæ are described, some of which indicate representative forms of the English Eocene tertiaries, although belonging to different subgenera; also new species of peculiar cycadeous plants, from the mesozoic coal strata; a palæozoic lepidodendron from the carboniferous sandstone of Gippsland, which is scarcely distinguishable from the *L. tetragonum*, Sternb., of the European palæozoic carboniferous deposits, and is probably identical with a plant from Queensland, referred by Mr. Carruthers to the Devonian *L. nothum*; and two remarkable starfish, from the upper silurian rocks belonging to the genera petraster and urasterella, the latter form nearly related to the *Uraster Ruthveni* of the upper silurian grits of Westmoreland. The determination of the Palæozic fossils by Professor McCoy fully corroborates the suggestions made some years since by Mr. Selwyn and his colleagues, derived from their laborious stratigraphical investigations as to the age of the gold-bearing rocks of Victoria. For Mr. Selwyn remarks, in the published Report of 1853—although he has not been able to detect any organic remains in these rocks, and has therefore no good evidence as to their precise geological age, but, judging from their lithological character and general appearance—he should consider them to be the equivalent of the cambrian or lower silurian strata of Great Britain, portions of which, as seen in North Wales, they precisely resemble. And again, in the Report for 1854, reiterates the same opinion, from having found abundance of organic remains both in the auriferous rocks of McIvor and in the clay slates, shales and sandstones near Melbourne, of which fossils a list of some genera and species were given; from which it appears that the labours of the geologist in the field were confirmed by the study of the palæontologist in the cabinet. It is the description of some of the specimens from the collections made by the staff of the Geological Survey of Victoria, under the direction of Mr. Selwyn, up to 1868, which form the subject of the present memoir, and which we hope will be as ably continued by Professor McCoy.

ON SPONTANEOUS GENERATION.*

THERE is perhaps no subject in the whole wide range of biological speculation on which so much has been written, so many eminent men have taken part in ardent controversy, or which has engaged scientific attention for so long a period as that of (the now somewhat disused term) spontaneous generation. We have had already two books on this most important process by Dr. Bastian, and now we have a third, which consists in great measure of a series of papers which have appeared during the past twelve months in the "Contemporary Review" and in the "Proceedings of the Royal Society." We have had to pronounce on the whole a somewhat unfavourable opinion upon the previous writings of this savant, and now we have to review the last evidence he has offered on this almost undemonstrable proposition. Dr. Bastian has received many hard blows in this controversy, but he has taken them all easily; and what is more to his credit, he does not appear anxious to return the blows. Indeed his book is written in the best possible temper, and that is saying a good deal considering the nature of the struggle. We may state at the outset that it seems to us as if the author might have said everything new that he has got to urge in favour of the doctrine he has taken up in at the utmost twenty pages; yet his remarks extend to no less than 186 pp. This is to be regretted; for many men thoroughly competent to judge of the evidence in favour or against his views will, we fear, throw the book down in wrath. However, it can't be helped, we suppose, and we must accept his arguments as they are given. But what, it may be inquired, has the author added to our knowledge of this subject? And to this question we cannot answer very much. Indeed, it appears to us—who are thoroughly impartial critics—that the whole book, so far as anything new is concerned, is to be read in about a quarter of an hour, from p. 168 to p. 184. And what does this portion tell us? Very little indeed. It shows us that two experiments were tried, in one of which "a strong infusion of turnip was rendered faintly alkaline by liquor potassæ," and a few bits of muscular fibre of a cod were added. In the other "a strong infusion of common cress, to which a few of the leaves and stalks of the plant were added," was the substance experimented upon. In both of these experiments the liquid, with its contents was placed in a hermetically-sealed flask and heated on a digester to a temperature over 230° for an hour, and then kept at a temperature of 70°–80° Fahr., in one case for eight, and in the other for nine weeks. Now what was the result? Dr. Bastian found that both fluids, which were rendered very slightly alkaline before boiling, had become decidedly acid, and that they contained a floculent deposit, which deposit was examined under a $\frac{1}{12}$ inch immersion objective and gave results which are depicted in a plate forming the frontispiece of the volume. This plate shows bacteria, peculiar monad-looking bodies, and what Dr. Bastian considers to be "Torula corpuscles" and "Fungus spores." Now, in the first place, we

* "Evolution and the Origin of Life." By H. Charlton Bastian, M.A., M.D., F.R.S., Professor of Pathological Anatomy in University College. London: Macmillan, 1874.

have to ask, is it possible that no aperture existed in the flask? and to this the author says no, for on applying the blow-pipe it was found that the glass was drawn in, there of course being therefore "a partial vacuum" previously. This may be, but of course one knows how readily glass would be blown in by the blowpipe even if no vacuum were there. However, we let that pass. Then there arises the question, How soon after the flasks were opened were their contents examined? We assume that it was immediately after they were exposed to the air, but the author does not state so. Then again, when were the drawings made? was it immediately, or was it some time after? These all appear small questions, but they have a considerable importance. Lastly comes the most important query of all, How do you know that your temperature was sufficient to destroy life? We are aware that Dr. Bastian will reply, "Because I find that a lower temperature was sufficient to destroy those very minute animals—those monads which had been developed in the flask." But then we would inquire, How do you know that you destroyed by your application of 230° Fahr. for about an hour not only the parent bacteria and other fully developed organisms, but likewise the young offspring of these? That is the point on which we think Dr. Bastian's argument is weakest. He may have destroyed the parent organisms, but how does he know that he also destroyed their germs. For we know that they will—from analogy—tolerate a higher temperature than their parents without undergoing the slightest injury. So far as we can see, Dr. Bastian has made one point in his favour, but it is a very slight one, and it must be further developed before we shall be content to believe in his hypothesis.

A NEW MODE OF LEARNING PHYSICS.*

WHETHER the plan proposed in the present volume is likely to be a successful one, time can alone disclose. But that the scheme is one which we can highly commend is altogether unquestionable. The book is upon experimental physics, but they are taught after a fashion perfectly new in this country, and which we trust may prove in the highest degree successful. It is at once a book in which are combined the knowledge to be derived from the lecture-room with that from the purely physical laboratory. Professor Weinhold, of the Royal Technical School at Chemnitz, has been at great pains to construct a book so that the student shall not only learn the principles of the science, but shall have the opportunity of putting all those principles into practice. This is done by first explaining the scientific facts and then showing the reader how he may set to work to put the ideas he has learnt into force. Of course, in order to work properly at such a book as

* "Introduction to Experimental Physics, Theoretical and Practical, including Directions for constructing Physical Apparatus and for making Experiments." By A. F. Weinhold, Professor at the Royal Technical School at Chemnitz. Translated and Edited by B. Loewy, F.R.A.S., with a Preface by Professor G. C. Foster, F.R.S.; illustrated by three coloured plates and 404 woodcuts. London: Longmans, 1875.

this, the student will require a large amount of tools and apparatus, and a considerable degree of patience and perseverance. A list is given of the instruments required, with the cost of each, so that the reader who can afford it and has time to allot to the labour, may set about studying experimental physics at once. But we fear the needy man will have the difficulty of cost in his way, and this of course may deter him from the undertaking. But we do not see why, either at college or in an advanced school, a subscription might not be got up by various students, and so the expense would be trifling while the advantage would be as great to all. The book before us is of considerable size, being large 8vo. and extending to pp. 850. It deals with the subjects of mechanics, hydrostatics, pneumatics, light, electricity, galvanism, &c., and heat. And these several branches are dealt with very fully, and with ample illustrations, and appended remarks as to the nature of the work which must be done by the student in preparing for experiment. The editor, too, Mr. Benjamin Loewy, F.R.S.A., has done his work with care, and has given an admirable translation of what must have been a very difficult task to render in English. The preface by Professor Foster shows the importance of the plan which Herr Weinhold adopts.

MUSHROOMS: THEIR ANATOMY AND USES.*

WE certainly did not think that so much could be said on the subject of this volume as the book contains; but we have been enlightened, and that, too, in the most forcible manner. It must be admitted that the work which Mr. Cooke has completed is a most valuable one: and, in addition, is most interesting reading. He has written a full account of fungi, their nature, structure, classification, uses, notable phenomena; their spores, germination and growth, sexual reproduction, polymorphism, influence and effects, habitats, cultivation, geographical distribution, and lastly their collection and preservation. It will be seen from this list of contents that it is essentially a work on the natural history of the fungi, one which deals with their manners and habits, and not one which has to do in the slightest way with species. It is therefore a book which everyone who loves biology must procure, and it is one too which any person who has an ordinary English education may read with the greatest advantage to himself. That it must have a large sale is unquestionable; for it is the only book of the kind we know of, and it is written by the very highest authority in the country save one, and that one (Mr. Berkeley) has gone over the proofs, and added notes here and there. It covers about 300 pages, and is illustrated by more than 100 woodcuts, which are taken from the writings of men like Van Tieghem, Greville, Boudier, De Bary, Tulasne, Currey, &c. Of all the various chapters, every one of which is full of interest, there are two or three to which we may specially refer, as they appear to us to be pre-eminently good. And

* "Fungi: their Nature, Influence, and Uses." By M. C. Cooke, M.A., LL.D. Edited by the Rev. M. J. Berkeley, M.A., F.L.S. Henry S. King & Co., 1875.

first we would refer to the section devoted to so-called notable phenomena. Under this heading we are treated to a very exhaustive account of the peculiar phosphorescence of fungi. Among many quotations is one from Tulasne of interest, which shows that almost all parts of the fungus are in some cases brilliant with phosphorescent light. He says, "Among the first Agarics which I examined, I found many the stipe of which shed here and there a light as brilliant as the hymenium, and led me to think it was due to the spores which had fallen on the surface of the stipe. Therefore, being in the dark, I scraped with my scalpel the luminous parts of the stipe, but it did not sensibly diminish their brightness; then I split the stipe, bruised it, divided it into small fragments, and I found that the whole of this mass, even in its deepest parts, enjoyed, in a similar degree to its superfices, the property of light." And Mr. Cooke cites many other cases both from his own experience and that of others, of this curious property. We should have been glad had he been able to give us a fuller account of the chemistry of the process, though we doubt not it is simply, as Sir H. Marsh showed in the case of animal luminosity, phosphorus slowly combining with oxygen. Mr. Cooke does not appear familiar with Mr. Sorby's curious researches on the subject of the spectra of certain colouring matters in plants, some of them fungi we think, but he has recorded several very interesting facts nevertheless. In the chapter on the influences and effects of fungi the author mentions some very remarkable instances of the poisonous action of these plants, one case, that of the Fly Agaric being excessively singular, viz. that to Englishmen it is excessively poisonous, while the Russians eat it freely. We would quote a portion of the last chapter, but we have already exceeded our allotted space, else we should like to have given the author's advice to the collector of fungi. But after all it is needless, for we are sure that all who are interested in the matter must procure the book, which is not only the sole work on the subject, but is as good as a book can be.

DESCENT AND DARWINISM.*

HERE is a book which contains nothing new, but which is nevertheless a most valuable addition to our literature, from the extremely able and withal excessively popular manner in which it puts before the reader some of the greatest speculations of the age. It is essentially a Darwinian type of book, written by one who is familiar with the subject; and if it has been written in English by its German author, he is assuredly a master of our tongue. There is not a passage in the work which is not given in the most excellent English. The first few pages explain the author's views, and show us in a moment the style of matter that we may expect. In these Professor Schmidt takes very severely to task the words of Luthardt, in which it is asserted that in considering questions of ethics we must adopt

* "The Doctrine of Descent and Darwinism." By Oscar Schmidt, Professor in the University of Strasburg. London: King & Co., 1875.

a different method to that of natural science, for its domain "is higher than that of physics, and therefore a higher causality, which physics have *no right to criticise*, has suspended the chain of cause and effect with which you anatomists are familiar." Dr. Schmidt is of quite a different opinion, holding the view of Pico della Miranda, that philosophy seeks, theology finds, and religion possesses the truth. The chapter on the phenomena of reproduction, though it is short, shows the writer to be possessed of the most modern views on the subject, for we observe that he places the sponges close to the Cœlenterata, where Hæckel's and other researches show that they should be ranked. The subject of prophetic types is also severely handled by the author. Speaking of Agassiz, he says: "The pterodactyle is, for example, supposed to stand in this relation towards the bird. Does this quibble aid in the comprehension of either one or the other? Is any natural idea obtained if, besides the prophecy of the pterodactyle, the geologically antecedent insect is regarded as its prophet, or the bird as the forerunner of the bat. *There is no sense at all, unless the prophet becomes the progenitor, which in these cases cannot be supposed.*" All through is the book most interesting reading, and it will be thoroughly admired by all those who sympathise with Darwinism, having many of the advantages and none of the abuses of Louis Büchner's well-known work.

HARVESTING-ANTS AND TRAP-DOOR SPIDERS.*

It is with the deepest regret that we have to announce the death of the distinguished author of this supplement to a work which will ever live among those who are interested in natural history pursuits, as a marvel of the draughtman's skill and the natural historian's writing. Toward the close of the year Mr. Moggridge passed away, a victim to that plague of modern diseases—phthisis. While he lived, however, there is no doubt that he worked, for this book was issued just before his death, and was intended as a sort of supplement to his larger essay on the same subject. Here will be found, as in his earlier volume, most marvellously natural drawings of the several curious forms of dwellings of the trap-door spiders, which he had not described in the earlier work; and the book is full of his account of the nests and of the habits of the peculiar harvesting-ants. It is further supplemented by an account, in technical terms, of the spiders, which has been drawn up by the Rev. O. Picard-Cambridge. It is a wonderfully graphic description that which the author gives, and we defy anyone with a naturalist's tastes to read a page without becoming engrossed in the subject. The following are a series of remarks which Mr. Moggridge has put into a categorical shape, and which are of great use:—"(1) Do *any* ants collect and store seed in Switzerland, Germany, North France, England, or indeed in any of the

* "Supplement to Harvesting-Ants and Trap-door Spiders." By A. T. Moggridge, F.L.S., F.Z.S.; with Specific Descriptions of the Spiders, by the Rev. O. Picard-Cambridge. London: L. Reeve, 1874.

colder parts of the world? What are the habits of *Atta structor* and *A. barbara* when living as they are known to do in Switzerland, Germany, and Northern France? How do the ants contrive to preserve the seeds in their granaries free from germination and decay? How are the seed-stores of tropical ants disposed below ground, and of what do they consist? and lastly, Do harvesting-ants exist in the southern states of North America, in Australia, New Zealand, or at the Cape?" The book shows how much may be done by anyone who will determinedly follow out a course of natural history studies; for here an invalid has, by constant research, produced a volume which is of the very highest interest and value as an addition to our works on practical investigation.

RELIGION AND SCIENCE.*

CERTAINLY it is long since a book with such an important bearing on society and so thoroughly scientific, and therefore impartial, was placed in the hands of the British public, as that of Professor Draper's "Conflict between Religion and Science." And assuredly very few men could have been found so thoroughly able to criticise the scientific side, and yet to enter freely upon the literary, as the learned Professor of Physiology in the University of New York. Dr. Draper has shown, both by the publication of an admirable book on physiology and by the issue of a work which is now in many modern languages, "The History of the Intellectual Development of Europe," that he possesses in no ordinary degree the kind of skill required in a writer on such an important topic as that he has taken in hand. And he has exhibited his power, we think to the greatest extent possible, in the construction of the present book. And what, it will be asked, has he done? It is certainly hard in a very brief space to point it out, but nevertheless we shall endeavour to indicate what the author of the work before us has done. First, he sketches the early introduction of science, which he clearly shows was due to the Alexandrians, and this was prior to the introduction of Christianity. Then he dwells on the influence of Christianity, and shows how one of its first effects was the extinction of the Alexandrian schools. Next he points to the efforts of Mohammedanism, and proves that it was in the main the doctrine of the unity of God, and shows how it severed much of Asia and Africa, and also Jerusalem, Alexandria, and Carthage, from the Roman empire. This event, he tells us, was followed by the establishment of schools, colleges, and libraries throughout the dominions of Arabia. The result of this was "a second conflict, that respecting the nature of the soul. Under the designation of Averroism there came into prominence the theories of emanation and absorption. At the close of the Middle Ages the Inquisition succeeded in excluding these doctrines from

* "History of the Conflict between Religion and Science." By John William Draper, M.D., LL.D., Professor in the University of New York. London: Henry S. King, 1875.

Europe, and now the Vatican Council has personally and solemnly anathematised them." Meanwhile Galileo led the way to another overthrow of the church by bringing it to confess that his ideas and not its were correct. Then came the mighty power of Luther and the Reformation which has left at least one-third of Europe, and that the conquering third, exclusively Protestant. Professor Draper thinks that we are now in the same position that Arabia had reached in the tenth and eleventh centuries, and that the questions which now are for discussion are *Evolution*, *Creation*, and *Development*. However, we don't quite agree with him in this opinion. Undoubtedly the question at present that engages attention is evolution, but we cannot conceive that the Arabs of the eleventh century had reached that doctrine. Besides his account of those several periods of the world's history, which is given in glowing and eloquent language, the author adds three chapters on the following questions which are of extreme interest. These are: (1) An examination of what Latin Christianity has done for modern civilization; (2) a corresponding examination of what science has done; and (3) the attitude of Roman Christianity in the impending conflict, as defined by the Vatican Council. On all these points those who are sufficiently impartial to give ear to an unbiassed but clever observer will read what Professor Draper has to say. Those who are undevoid of prejudice will, of course, not receive anything that is opposed to their pre-existing views.

THE PROTOPLASMIC THEORY OF LIFE.*

WE think it is to be regretted that Dr. Drysdale should have attempted such a book as this, for it certainly leaves the matter he has taken up exactly where he found it. Still it is an unquestionably clever work, which discusses the various views that are held on the subject of life, by opposing schools of thought, with a great deal of impartiality. But the author might have said at the first that he believed in a God, without any argument either in his favour or in opposition from scientific matters. Then the reader would not have exclaimed, Why is so much science brought to bear on the matter? Dr. Drysdale discusses nothing that has not been over and over again treated of, and he is just as enlightened on the question of protoplasm as any of us. We think it is a pity that he should have given up so much time to the composition of this book, when he might have expended the time, as he has done before, in valuable microscopical researches.

* "The Protoplasmic Theory of Life." By John Drysdale, M.D., F.R.M.S., Author of the "Physiological Action of Kali Bichromicum." London: Ballière, 1874.

THE FLORA OF COLORADO.*

THE geological survey of the Territories under the direction of Dr. F. V. Hayden is not merely restricted to pure geology and geography, for the other branches of natural history are equally and carefully attended to. The "Synopsis of the Flora of Colorado" has been prepared by Professors Porter and Coulter from collections chiefly made during the progress of the survey in 1861 and succeeding years. More than 1,250 species are enumerated, of which descriptions, as well as of the orders and genera are given of those not contained in "Gray's Manual" and other botanies of the States east of the Mississippi river.

The greater number are Phænogamous plants. There are twelve species of Coniferæ, and about thirty vascular cryptogams; the 130 species of mosses are described by Professor Lesquereux, which, considering this class of plants was not made a specialty by the botanical collectors, as well as the comparative bareness and absence of humidity of the eastern slopes of the Rocky Mountains, forms a remarkably rich and interesting catalogue. The lichens and fungi are described by Messrs. Willey and Peck. The work is intended to be a type of a series of "handbooks" of different branches of natural history, to be published from time to time for the use of students all over the country, and forms a valuable contribution to our knowledge of the flora of the region.

RELIQUIÆ ACQUITANICÆ.†

THIS number of the "Reliquiæ" contains two or three very interesting papers, one good plate of flint weapons, and several remarkably excellent woodcuts. First is a translation of M. Lartet's paper on an elephant's carved tusk, which is taken from the "Comptes Rendus" of the French Academy. Then follows a paper by the editor on a curious carving of a glutton on an antler from one of the Dordogne caves. This contains an excellent sketch of the glutton, drawn by Mr. N. L. Austen, who, we regret to say, has died through a horse-accident before this number appeared, and who was the author of an excellent paper in this number of the "Reliquiæ" on the "Scandinavian Reindeers." The final communication is by M. le Dr. H. E. Sauvage of Paris, on the subject of "Fishing during the Reindeer Period," which is a very good paper, containing some startling fishing statistics by Mr. Lord.

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* "Geological Survey of the Territories.—Miscellaneous Publications, No. 4. Synopsis of the Flora of Colorado." By T. C. Porter and J. M. Coulter. Washington, 1874.

† "Reliquiæ Acquitanicæ." By E. Lartet and H. Christy. Edited by T. Rupert Jones, F.R.S. Part XV. London: Williams & Norgate.

"A Dictionary of Physical Science." Edited by G. F. Rodwell, F.R.A.S., F.C.S. London, E. Moxon, 1871.—We do not know why this book was not sent to us before, but it is better late than never. At first we were disposed to underrate it, but now must confess that it is exceedingly well done, and is a really admirable dictionary of physical science. We have only one objection to raise, and that is as to the type it is printed with. It is infinitely too small. Among the contributors are Mr. Crookes, F.R.S., Professor Guthrie, Mr. R. A. Proctor, and Mr. C. Tomlinson.

"Synopsis of the Acrididæ of North America." By Cyrus Thomas, Ph.D. Washington, U.S.A., 1873.—Here is an admirable work in 4to., of 260 pages, which deals in the fullest manner with the grasshoppers of the United States. It is preceded by a description in full of the anatomy of the insects, and is followed by an excellent plate and a valuable glossary. The great bulk of the volume includes a description which is full and exact of the several species of this group. It is to be followed by other works on the botany and zoology of the United States, by equally competent writers.

We have received the following:—"The Philosophy of Voice," by Charles Lunn (London, Baillière, 1874); "The Transit of Venus: its Meaning and Use," by T. Budd, F.R.S.A. (London, Longmans, 1875); "Professor Volkmann on Antiseptic Surgery" (Edinburgh, Oliver & Boyd, 1875); "The Patent Question in 1875," by R. A. Macfie (London, Longmans, 1875); "Asiastic Cholera, 1874," by Surgeon-Major R. Pringle, M.D. (Edinburgh, Oliver and Boyd, 1874); "A New Method of Signalling on Railways," by Sir David Salomans (Southborough, Baldwin, 1874).

SCIENTIFIC SUMMARY.

ASTRONOMY.

TRANSIT *of Venus.*—Since our last Summary appeared, news, more or less complete, has been received from all stations. The following list of stations, partly taken from one compiled by the Astronomer Royal, includes all those at which observations were successfully made:—

Sandwich Islands.—Honolulu and Waimea.
China and Japan.—Pekin, Chefoo, Saigon, Kobe, Nagasaki, and Yokohama.
Russia in Asia.—Wladiwostock, Ariandа, Tschita, Nertschinsk, Possiet, Haborowka, and Kiachta.
India.—Roorkee, Indore, Calcutta, Kurrachee, Mooltan, Mussoorie, Umballa, and Maddapore.
Syria and Persia.—Beyrout, Ispahan, and Teheran.
Egypt.—Mokattam Heights, near Cairo, Alexandria, Suez, and ruins of Luxor, Thebes.
S.E. Europe.—Clausenberg, Maros Vasarhely, and Jassy.
Java.—Buitenzorg.
Australia.—Adelaide, Melbourne, and Sydney.
Tasmania.—Hobart Town.
New Zealand.—Queenstown.
Southern Islands.—Auckland Islands, St. Paul's Island, New Caledonia, Kerguelen Island, Mauritius, Rodriguez, and Réunion.
Cape of Good Hope.—The royal observatory.

The Delislean operations for ingress were moderately successful; those for egress, owing to the unfortunate prevalence of bad weather at Major Palmer's station in New Zealand, were less successful. In fact, but for the success of the Germans at Auckland Island (one of the geographical myths), operations would have failed at all the best Delislean southern stations, and thus the northern success in Egypt would have been rendered useless. Halleyan operations, including under that term those photographic and heliometric operations which were conducted at stations whence the whole transit could be seen, were favoured by fortune. It is not too much to say that the determination of the sun's distance actually effected from the observations made last December, will owe five-sixths of its value to the observations made at stations where the whole transit could be seen. It is

disappointing to find that no provision was made for photographic and heliometric work at Cape Town, which was absolutely the best southern station of all for mid-transit observation.

Observations by Lord Lindsay's Party at Mauritius.—Lord Lindsay's preparations were so complete, that a special interest attaches to the observations made by his party. We quote nearly in full his account, in a letter addressed to the Astronomer Royal:—

"The morning of the 9th was cloudy before sunrise and for a short time after. The first external and first internal contacts were missed from this cause. We did not see the Sun until 1 h. 2 m. after the first external contact, when it came out for a few minutes, when photographs and measures were obtained. It was not till 8 A.M. (local mean time) that it became fairly fine, and remained so, with small periods of cloud obscuration, until the end of the transit.

"*Photography.*—I took 271 plates, out of which number perhaps one hundred (100) will be of value; cloud and the very high temperature of the camera were much against me. Temperature varying from 96° to 116°.

"*Heliometer.*—Mr. Gill obtained five (5) complete determinations of greatest and least distances of the centres of the Sun and Venus, besides nine measures of cusps and two separate determinations of the diameter of Venus near the end of the transit.

"6-*in. Equatorial.*—Dr. Copeland obtained with this equatorial and the Airy double image micrometer, fifteen (15) measures of least distance of Venus from the Sun's limb, and ten (10) measures of cusps. Dr. Copeland also observed the last internal and external contacts with this instrument.

"The images of Venus, one brought into contact with the other, and then slowly rotated by the position-circle, showed no symptom of oblateness (ellipticity). Dr. Copeland observed the second internal contact with full aperture and first surface reflecting plate. The second external contact was observed with the double-image micrometer: the images superposed on account of faintness of the images.

"4-*in. Equatorial.*—The last internal contact was observed with this instrument and the Merz polarising eye-piece by Mr. Gill. He also observed the last external contact with the heliometer.

"Both Dr. Copeland and Mr. Gill agree that the contacts of Venus and the Sun are remarkably similar to those seen on the model. They also agree that any phenomena which could be classed under the head 'Black Drop' took place and disappeared within a period of five (5) seconds.

"*Time.—Transit Instrument.*—Very accurate determinations of the time were obtained on the six nights previous; and one star and azimuth-mark on the night following, by Dr. Copeland with the 4-in. reversing transit. All the photographic exposures are automatically registered on the chronograph by a method which gives the actual duration of the exposure. The heliometer observations were also registered thus: Dr. Copeland observed eye and ear—all other observations (photograhic and heliometric) were also observed eye and ear as a check on the chronograph. During the actual work of the transit I had eight assistants, not counting myself or Mr. Davis. Mr. Gill had six, including the Hon. M. Connal, Surveyor-

General, to whom I am much indebted for valuable assistance. Dr. Copeland had three assistants. All these men formed part of the crew of my yacht—whom I have trained to the work.

"I am happy to say that the German expedition, under Dr. Low, got the third and fourth contacts, and three (3) complete sets of heliometer measures. Also, Mr. Meldrum got the second and third contacts, though rather uncertain as to the first internal contact, owing to cloud. Thinking that, possibly, he would not be able to get time determinations on the night of the 9th, I sent him a box of nine chronometers, which I have left with him for the rating of his clock.

"P.S.—One of my photographs shows the second *internal contact* beautifully."

In summing up the results of the transit observations, we must assign a first place to Lord Lindsay's work among all that has been accomplished at single stations. To the Americans must be assigned the first place among the nations, not only as respects the cost and completeness of preparations, but also for the skill and judgment shown in their preliminary investigations. The Russians provided (and well) for the greatest number of stations. The French pre-eminently distinguished themselves by their daring in occupying stations of danger and difficulty, so dangerous indeed that the British Admiralty declared them inaccessible. The Germans and Americans did well also in this respect. Great Britain, at one time hopelessly in the rear, drew nearer at the last to her just position, but did not quite attain it.

General Meeting of the Astronomical Society.—It seems fated that the general meetings of this society should be disturbed by unpleasant proceedings. In February 1873 there occurred the attack on five members of the council by Messrs. Lockyer, Strange, and Pritchard, which ended in the defeat of this trio. This attack had its origin in the proposed observatory for determining the (imagined) laws according to which sunspots rule the weather—a proposal to which the five members attacked had opposed an energetic resistance. In February 1874 the dissentients had fallen out among themselves. Professor Pritchard had not duly considered the wishes of the other two in connection with the new observatory at Oxford; and Colonel Strange rose in his place and denounced his former associate and ally as unworthy of his position as a vice-president of the society; but, Professor Pritchard being absent, the attack was very properly silenced by the chairman of the meeting. This year the difficulty arose out of another matter. For three years certain valuable instruments lent by the Astronomical Society to the eclipse expedition of December 1871 had been lost to sight. Messrs. Dunkin and Proctor had in vain written to the Secretary of the British Association (under whose auspices that expedition was despatched) to gain tidings of the missing instruments. But early this year, in preparing the report of astronomical proceedings for the preceding year, Mr. Dunkin found in the report of the Melbourne Observatory a letter by Mr. Ellery, thanking Mr. Lockyer for his generosity in presenting these instruments to that observatory. The meeting was naturally indignant when they heard this news, one gentleman going so far as to quote the statute Vic. 24 & 25; and though Mr. De La Rue said this was not warranted by Mr. Lockyer's

action, the voice of Professor Pritchard was heard protesting loudly against his former ally. The matter was hushed up at this time, however; and we are glad to hear that the British Association has undertaken to refund to the Astronomical Society the value of the departed instruments. It may perhaps be but fair to add that something was said of such a proceeding two years ago—the question at least was asked by the British Association Eclipse Committee whether the instruments might be given away if their value was made good to the Astronomical Society. But somehow it so chanced that permission to this effect was not awaited, and (unknown, we feel assured, to the Secretary of the British Association) the instruments were made over as above stated, while the trifling preliminary of paying for them was omitted. Generosity is an excellent thing, and zeal for science leading a man to provide an observatory at the antipodes with instruments, cannot—viewed abstractly—be too highly commended: but making a present of property belonging to others is a proceeding which appears open to some degree of question.

Eclipse of April 6.—Government made a grant of 1,000*l.* to the Royal Society for the observation of this eclipse, and a party sailed from Southampton on February 11, in charge of Dr. Schuster, Dr. Vogel joining at Suez and Dr. Janssen at Singapore. (The remarks in the last paragraph are rather unpleasantly illustrated by the fact that neither the Astronomical Society nor Greenwich Observatory has lent a single instrument on this occasion.) Some dissatisfaction has been expressed because the sum granted by Government was given at the request of the Royal Society, instead of being entrusted to the Astronomical Society and the Astronomer Royal. But, considering the nature of the Astronomer Royal's original scheme for observing the recent transit, and the slowness with which he receded from an untenable position, it can hardly be wondered at if an arrangement was adopted in this instance which, while giving him a vote, left the arrangements freer from his control than they could have been if submitted to the council of the Astronomical Society. Unfortunately, the arrangements actually made have not been benefited by the change. Some of the instructions given to the observers seem simply absurd, and others are unsafe. It is difficult to understand how a committee, on which men so experienced as Airy and Stokes had seats, should have countenanced a programme one half of which is characterised by ignorance of well-established physical laws. Vogel's plan for photographing the corona by polarised light (which bad weather prevented him from applying during the Mediterranean eclipse) is to be tried. (We should have been glad to have seen his name mentioned.) The arrangements for photographing the spectral images of the corona and sierra, seemed, as originally stated, to be so bad as not to admit of being made worse. But, as described in the directions, they have certainly received the final touch which shows the master. It has been shown that the chances were strong against any results at all being obtained by this method. But it appears now that to ensure success the operator is to judge by the development of one plate how long to expose the next. Considering that totality will not last more than four minutes, and that the experimental development of exceedingly faint objects will require time—certainly not less than a minute and a half—while the first exposure is to be one minute,

the question naturally arises, how is the longer time which development may probably suggest to be obtained. Will the sun and moon stand still to oblige Mr. Joseph Lockyer, as it once did, we are told, to help Joshua? May we be permitted to recall an experience of the eclipse of 1871? On that occasion an enthusiastic observer, having collected for his own use all the best instruments, rushed during totality from one observation to another (he called these "strategic movements," however), endeavouring during the two minutes of totality to make *nine* distinct observations. The sun and moon not standing still, he naturally missed the whole set. Is it too much to say, that unless Dr. Schuster and his assistants wisely take the matter into their own hands on the present occasion, the Royal Society expedition runs great risk of failure similarly complete?

Fortunately the Indian Government may be expected to send observers who will take some good photographs of the corona, while Davis, the skilful photographer of Lord Lindsay's party, will probably achieve even better results.

Periodicity in the Value of the Sun's Diameter.—In the report of the Astronomical Society the following occurs: "The question whether the sun's apparent diameter is liable to periodic changes has frequently occupied the attention of astronomers. The subject has been investigated by Von Lindenau, Bessel, and Bianchi, and more recently by Le Verrier, Secchi, Wagner, and Auwers. Lindenau was led to the conclusion, by a discussion of the Greenwich observations from 1750 to 1755, and from 1765 to 1786, that the sun is an ellipsoid, with a compression of $\frac{1}{276}$ to $\frac{1}{140}$. Bianchi, apparently without being acquainted with Lindenau's research, found the solar compression $\frac{1}{220}$, but by changing his method of investigation he obtained values for this quantity varying from $\frac{1}{1325}$ to $\frac{1}{110}$. Bessel, however, considered that a progressive shifting of the wire-frame of the Greenwich transit-instrument would account for the apparent periodicity in the values of the solar diameter. M. Le Verrier, after a careful investigation, came to the conclusion that no real periodic variation in the sun's diameter existed equal to 0″·02. More recently, Padre Secchi, considering that the active forces known to be in progress on the surface of the sun might very possibly produce changes in the volume of the luminous matter composing the chromosphere, announced the result of some researches on which he had been engaged in conjunction with Padre Rosa. He concluded that the variations in the solar diameter were the most apparent when the activity of the forces on the surface of the sun was greatest; and he considered that, as these variations were frequently more than 3″ in amount, they could not be accounted for by mere errors of observation. Dr. Auwers, however, who has since thoroughly examined the methods adopted by Padre Secchi, gives as his opinion that the foundations of the theory employed by the latter are so unreliable that, for the present, these results cannot safely have much weight attached to them. Dr. Auwers, anxious to have an independent series of observations as the basis of his examination, obtained from the Observatories of Greenwich, Oxford, Paris, Brussels, Washington, Königsberg, and Neuchâtel, a large number of measures of the solar diameter observed during the same period as those by Padre Secchi at Rome.

"With regard to the connection of the value of the sun's diameter with

the solar-spot period, Dr. Auwers has also examined the Greenwich observations of Bradley and Maskelyne, and their assistants, as well as some of those made at Königsberg by Bessel, and at Dorpat by W. Struve; but his result is a negative one. He has also compared the Greenwich solar diameters observed from 1851 to 1870 with Dr. R. Wolf's relative number of the solar-spot conditions; and his conclusions are that, 'in the fluctuations of the observed values, both for the horizontal and vertical diameters, and the difference between the two, no dependence upon the variations of the degree of activity, and therefore no indication whatever of the reality of these fluctuations, can be perceived.'

"The evidence thus far seems to negative the existence of any periodical changes in the sun's diameter of sufficient magnitude to be detected from the ordinary meridional observations of the different limbs of the sun. This negative evidence is much strengthened by the results of an extensive comparison, by Professors Newcomb and Holden, of the horizontal and vertical diameters deduced from the observations of the sun at Greenwich and Washington from 1862 to 1870, the transits of the first and second limbs having in this interval been registered on the chronograph. The total number of observations discussed amount to 1,813 of the horizontal diameter, and 1,826 of the vertical diameter. The principle of the method is given as follows:—'Suppose we have two series of observations of the sun's diameter made simultaneously at two different observatories, so that each observation of the one series is accompanied by a simultaneous one of the other series. Then, if the outstanding difference between each measure, and the mean of the whole series to which it belongs, is due entirely to the accidental errors of observations, there will be no relation between the differences of the two series. But if a portion of the difference is due to an actual change in the sun itself, the differences which are positive in the one series will be accompanied by a preponderance of positive differences in the other series. For on the days when the sun is larger than the average, the probability of finding a positive correction will be more than $\frac{1}{2}$ at each observatory, and hence the probability of an agreement of sign will be greater than $\frac{1}{2}$. If the probability in each case be $\frac{1}{2}+a$, it is easy to see that the probability of an agreement will be $\frac{1}{2}+2a^2$. Our results should, however, depend not on a simple enumeration and comparison of the signs of the residuals, but also on the magnitude of the latter, and we may secure this dependence by taking the algebraic product of each residual of the one series by the corresponding one of the other. If the residuals are purely accidental, the mean value of these products should approximate to zero as the number of observations is increased; while, in the case of actual variability, it will approximate to some positive limit.'

"As many observers were engaged in these observations, it was found necessary to correct the apparent error of the ephemeris diameter for the personal error of the observer, and tables are given containing the adopted errors for each year for each observer, both at Greenwich and Washington. The conclusion to which Professors Newcomb and Holden have arrived seems to be that, whatever apparent variations of a periodic nature in the sun's diameter occasionally occur, they are probably the result of chance; and that it is clearly shown by their investigation, based upon so large a number

of observations, that, if any, only the slightest and uncertain indications of periodicity are exhibited."

Oppositions of Jupiter and Mars.—On April 27 Jupiter will be in opposition to the sun; on June 20 Mars will be in opposition, but not at all favourably placed for observation, having great southerly declination.

BOTANY.

A Fungus Show.—According to a late number of "Grevillia," an exhibition of Fungi at Munich took place in the "Crystal Palace" some time ago, and was visited by nearly 50,000 persons. Of species, 141 were represented by means of 1,033 specimens. The arrangement was a systematical one, and every species had its Latin and vulgar name, and other notes, written on a ticket. The edible fungi had white tickets, the venomous sorts green ones, and the indifferent red ones. A lecture, or demonstration, was also given on edible and venomous fungi, their cooking, and what to do in a case of poisoning by them. There were also joined to the exhibition a great many microscopical specimens of parasitical fungi, which do damage in the rural economy. Drawings of the growth and development of these minute plants were made by Professor Engler. The list of fungi exhibited is published in full in the "Gardeners' Chronicle." The absence of such species as *Agaricus arvensis*, *Russula heterophylla*, *Agaricus personatus*, *Marasmius urens*, *Panus stypticus*, *Polyporus squamosus*, *Craterellus cornucopioides*, was very singular and inexplicable.

Variation in the Water contained by a Plant.—At the late Botanical Congress which was held at Florence, M. Galeznoff gave the result of his researches in calculating the amount of water contained in the different parts of a plant. By dividing a trunk into a number of pieces from the base upwards, he found invariably that the quantity of water increases from the base towards the summit. Of the four species studied by him, he found *Pinus sylvestris* contained most moisture in the trunk, and Acer the least. Betula and *Populus tremula* were intermediate. In Pinus the bark is drier than the wood, and in Acer more moist. In Betula it is drier in the winter and spring, and more watery in summer and autumn. The contrary takes place in the case of the poplar. In the branches the same law holds good, but their bases are drier than the portion of the trunk from which they take their rise; and the petioles are more watery than the leaves. In the flowers, the perianth, the filaments and the styles contain more water than the anthers.

A new Edition of an old Work on Hymenomycetous Fungi: Epicrisis Hymenomycetum.—It is stated in Mr. Cooke's journal, "Grevillia" (December 1874), that the publication of the new and revised edition of this work will be hailed with pleasure by all mycologists, inasmuch as the course of time had deprived the former edition of much of its original value. Although confined exclusively to European species, this work will be indispensable to all who pursue the study of fungi with assiduity. We could have wished for more of the synonymy of the species, and a more extended

reference to figures, but perhaps this is too much to expect of the author at his advanced age.—We may add with satisfaction that the Rev. M. J. Berkeley has commenced a work which will supplement the present, and include all extra-European species of *Hymenomycetes*, and thus render complete what the illustrious Swedish mycologist has only in part accomplished. No one is so competent to undertake this as the authority who has taken it in hand, and we anticipate that in little more than twelve months, if health should be given him, we shall be in possession of the new Epicrisis.

Do Varieties wear out?—This important question is asked and answered in an able article in "Silliman's American Journal" for February 1875, by Dr. A. Gray, the eminent American botanist. He says there is a philosophical argument which tells strongly for some limitations of the duration of non-sexually-propagated forms, one that probably Knight never thought of, but which we should not have expected recent writers to overlook. When Mr. Darwin announced the principle that cross-fertilization between the individuals of a species is the plan of nature, and is practically so universal that it fairly sustains his inference that no hermaphrodite species continually self-fertilized would continue to exist, he made it clear to all who apprehend and receive the principle, that a series of plants propagated by buds only must have weaker hold of life than a series reproduced by seed. For the former is the closest possible kind of close breeding. Upon this ground such varieties may be expected ultimately to die out; but "the mills of the gods grind so exceedingly slow," that we cannot say that any particular grist has been actually ground out under human observation. . . . How and why the union of two organisms, or generally of two very minute portions of them, should re-enforce vitality, we do not know and can hardly conjecture. But this must be the meaning of sexual reproduction. The conclusion of the matter from the scientific point of view is, that sexually propagated varieties, or races, although liable to disappear through change, need not be expected to wear out, and there is no proof that they do; but, that non-sexually propagated varieties, though not liable to change, may theoretically be expected to wear out, but to be a very long time about it.

Transpiration of Plants.—The "American Naturalist" [Feb. 1875], (in a note furnished, if we do not mistake, by one of our contributors to the present number) states that Dr. W. R. McNab, of Dublin, has performed a fresh series of experiments on the rate of motion of the sap in plants, and the transpiration of water from the leaves. The plants selected were the cherry-laurel (*Prunus laurocerœus*), elm, and privet; and the results obtained were as follows: 1. That, under favourable circumstances, a rate of ascent of forty inches per hour can be obtained. 2. That, contrary to the generally received opinion, direct experiment has shown that the upward rapid current of water does not cease in the evening. 3. That checking the transpiration for a short time by placing the branch in darkness does not materially impede the rapid current of water. 4. That the removal of the cortical tissues does not impede the rapid current in the stem, which moves only through the woody (xyleus) portion of the fibro-vascular bundles. 5. That a well-marked rapid flow of fluid will take place in a stem after the removal of the leaves. 6. That fluid will rapidly flow downwards as well as upwards in the woody (xyleus) portion of the fibro-vascular bundles, as seen in a branch

in which lithium citrate was applied at the top. 7. That pressure of mercury does not exert any very marked influence on the rapidity of flow, in the one experiment made with a pressure of 110·53 grammes of mercury.

Respiration in Plants.—This is not the process by which plants decompose the carbonic acid of the air—a fact that was pointed out many years ago by Bernard. However, it has recently been explained by M. Corenwinder, of France, a well-known physiological botanist, who points out, from experiments on the maple and the lilac, that true respiration is always going on in plants, although it may be concealed by the greater activity of the true digestive process by which oxygen is given off.

What is Mace?—Dr. Asa Gray tells us, in "Silliman's American Journal," (Feb.) that the mace of nutmeg, once taken as the type of an *arillus*, was a good while ago distinguished as an *arillode*, or false aril, by Planchon, on finding that it developed from the micropyle, while a true aril is a growth from the hilum or summit of the funiculus. Hooker and Thomson's statement that the mace develops from both the micropyle and the hilium has been confirmed by Baillon ("Comptes Rendus," 78, p. 779, abstracted in "Rev. Bibliogr." of Bull. Bot. Soc. France, l.c.) The consequence is, that the distinctions between *arillus* and *arillode*, *caruncle* and *strophiole*, become not exactly superfluous, but systematically unimportant.

The Red-rot of Pines.—The "Academy" for March 6, giving an abstract of the contents of the "Botanische Zeitung," states that in the number for January 15 there is a brief report of the meeting of the Brandenburg Botanical Society, October 30, 1874. Professor Hartig spoke of the symptoms of decay exhibited by living forest trees. The "red-rot" (Rothfäule) of pines is caused by the penetration and diffusion of the mycelium of a fungus *Trametes Pini*, Fr., in the heart-wood, whose reproductive parts appear on the outer surface of the branches, especially in branch holes. The spores produced fall on the exposed surface of newly broken off branches, and thus it may soon become widely spread. The various species attacking other common forest trees, which colour the wood red, green, brown, &c., were also considered.

CHEMISTRY.

Granulated Iron in the Washing of Bottles.—There has been lately a paper published by M. Fordos on this subject. He points out the danger of using leaden shot in cleansing bottles intended to contain beverages, medicines, &c. In their stead he recommends fragments of iron obtained by clipping up iron wire, Nos. 16, 17, and 18 giving a quality suitable for phials, and No. 22 for wine bottles. These iron granules have been used on a large scale with very satisfactory results. If there is any fear of injuring the colour of choice white wines, granulated tin may be used.

The Corrosion of Leaden Hot-water Cisterns.—At a recent meeting of the Manchester Philosophical Society, Professor H. E. Roscoe read a paper on the "Corrosion of Leaden Hot-water Cisterns." He said that "as the question of the occurrence of lead in town water has been brought

forward in the daily papers, I condensed water containing oxygen upon the metal and the subsequent formation of the insoluble hydrocarbonate, and there can be little doubt that water drawn from such a cistern would be contaminated with lead."

Absorption of Gas by Iron Wires.—The absorption of gas by these when re-heated to redness, and then quenched in dilute sulphuric acid, is the subject of an important paper in a late number of the "Comptes Rendus," by M. D. Sevoz. It seems that in wire-drawing, when the maker has arrived at a certain gauge, he is obliged, in order to draw the wire finer, to re-heat to redness in cast-iron stoves, closed as hermetically as possible, and then to quench in water containing 2·3 per cent. of monohydrated sulphuric acid. It often happens that iron wire which has undergone these two operations, for instance, at No. 18 (34-10ths of a millimetre), becomes brittle when it has reached No. 8 (13-10th). If the wire is broken, and the fracture plunged into a glass of water, rapid and numerous bubbles of gas are seen to escape. The author has collected this gas, mixed it with air, and obtained a distinct explosion, but has not been able to decide whether it is carbonate oxide or hydrogen. The presence of a small quantity of this gas renders the metal brittle. When the wire-drawers meet with pieces of brittle wire they ascertain, by putting saliva upon the fracture, whether the brittleness is due to gas. If this is the case they lay the wire aside for five to eight days, when the gas is found to have disappeared, and the wire resumes its ordinary malleability.

Certain Properties of Weighted Black Silks.—The "Chemical News" of February 3, in noticing a paper of M. Persoz, says that the author shows that weighing—which began with the modest aim of making up the loss sustained in ungumming—is now carried to the extent of 100, 200, and 300 per cent. This increase of weight is produced by treatment with salts of iron and astringents, salts of tin and cyanides. The bulk is augmented proportionably to the weight. As a matter of course, the chemical and physical properties of the silk thus treated are materially modified. What is sold as silk is, in fact, a mere agglomeration of heterogeneous matters, devoid of cohesion, held temporarily together by a small portion of silk. The elasticity and tenacity of the fibre are sensibly reduced. From being in its natural state one of the most permanent of organic bodies, and sparingly combustible, it burns like tinder if touched with flame. It is, moreover, liable to undergo spontaneous decomposition, and to absorb gases with the evolution of heat, which sometimes leads to actual combustion. The adulterated silk when burning scarcely gives off the characteristic odour of animal matter. It leaves an ash of oxide of iron, exceeding 8 per cent.

Gold-lined Capsules and Crucibles, a cheap way of making.—Mr. J. L. Smith, of the United States, makes the following remarks in a paper on various subjects that he has communicated to the "Chemical News" (Feb.). He says: "While the analytical chemist cannot always indulge in every form of luxury of apparatus which might tend to facilitate and give precision to his researches, still they are very convenient and useful at times. Those who have had much to do with caustic potash and nitre heated to redness, know that silver vessels will not always answer their purpose. Under these circumstances gold vessels are very useful, but very expensive,

and I have for some time been using what might be called a compromise vessel, made of platinum lined with gold; not platinum gilt, but made in the following manner:—A thick sheet of platinum is taken and the requisite amount of gold melted on the surface; the whole is then rolled out to the proper thickness for capsules and crucibles, and these latter vessels then made out of this sheet. There was some little difficulty attending the making of the first vessels, but this was entirely overcome in the establishment of Johnson, Matthey & Co., Hatton Garden, London, where the vessels I use are made."

Certain Chemical Matters found in Snow.—In the "Comptes Rendus" (Jan. 4), M. G. Tissandier says, "that in the snow which fell between Dec. 16 and 25 last, he distinguished the presence of an abundance of foreign substances, including certain salts. The dry residue from the evaporation of a litre of snow-water was determined. Snow collected in a court yielded 0·212 grms.; from the towers of Nôtre Dame, 0·118 grms.; and from the country, 0·104 grms. The residue obtained on the evaporation of snow is an impalpable greyish powder, of which the organic matter, rich in carbon, burns brightly. The residual ash amounted to 57 per cent. in Paris, and 61 in the country. It consists of silica, carbonate of lime, alumina, chlorides, sulphates, nitrate of ammonia, and very appreciable amounts of iron. He suggests that a portion of the matter suspended in the air may have a cosmic origin.

Analogies between the Escape of Gases from Supersaturated Solutions, and the Decomposition of Certain Explosives.—M. D. Gernez concludes from his experiments that there is the strongest analogy between the escape of a dissolved gas, taking place on the surface of the solution into a gaseons medium, into which the gas passes as into a rarified atmosphere, and that decomposition of explosives which cannot, as in the case of oxygenated water, be ascribed to a particular catalytic force.—*Vide* "Comptes Rendus," Jan. 4.

Remarks on Maltose.—It would seem from a paper in the "Berlin Chem. Gess.," that Herr Schulze has re-investigated and confirmed the statement of O'Sullivan that the action of malt-extract upon starch produces, not dextrose as had been supposed, but a compound sugar having the formula $C_{12}H_{22}O_{11}$, which he called maltose. The sugar reduces the copper test only two-thirds as actively as dextrose, but possesses a much better rotatory power. Schulze's experiments were conducted with diastase, precipitated from malt-extract by alcohol. Starch paste treated with this, at a temperature of 60°, was rapidly saccharified. After concentration and precipitation of the dextrin by alcohol, the solution was evaporated to a syrup treated with alcohol, the clear solution poured off and evaporated over sulphuric acid. Crystals first appeared on the walls of the vessel, and finally the whole solidified to a crystalline mass. Recrystallised from water or alcohol, maltose retains crystal water, which is readily given up at 100°. In appearence, maltose resembles dextrose, but is distinguished from it by its composition, its reducing power, and its action on a polarised ray. By boiling with dilute acids it is converted into dextrose. It is therefore an intermediate product between dextrin and dextrose.—*See* "Silliman's American Journal," Feb. 1875.

Crystals of Glycerin.—These somewhat peculiar bodies are described by Herr von Lauge, in "Pogg. Annal." The "Chemical News" of Feb. 12 says, "that the examination of these crystals was attended with difficulty, as when taken out of the mother-liquor they melt away, and render the application of the reflecting goniometer impossible. They belong to the rhombic system; their elements are $a : b : c = 1 : 0{\cdot}70 : 0{\cdot}66$; the forms are 100, 011, 101, 111. Cleavage imperfectly perpendicular to the longitudinal axis, therefore parallel to a plane 010.

GEOLOGY AND PALÆONTOLOGY.

The Drift in Kansas, U.S.A.—The Rev. M. V. B. Knox has written a letter to Mr. Dana, which is published in "Silliman's American Journal" (Dec. 1874). He says that "the drift in Kansas is confined mostly to the northern half of the State, little having been found any distance south of the great Kansas Valley. North of this river, especially in the region north and west of Topeka, there are drift rocks of vast size. The prevalent kind of rock is red and flesh-coloured quartzite, with a mixture of conglomerate and trap; the mass is red quartzite. On the high prairie these boulders are sometimes from six to fifteen feet in diameter; yet in the north-east fourth of the State one may ride twenty miles over the prairies and not see one of so large size. Smaller boulders and pebbles are everywhere to be found in this part of the State."

The Hawaiian Volcanoes.—According to the recent statement of Mr. T. Coan, Kilauea has been very active for the greater part of the past year. The great South lake has been full and overflowing much of the time; and the great central depression of 1868 in the crater has been filled up by deposits about 200 feet, while the region around the great South lake (Halemaumau) is a truncated mountain, nearly as high as the outer upper edge of the crater Mokuaweoweo; the summit crater of Mauna Loa has been in action for eighteen months. For the most of the time the action has been violent. Of late it has decreased, and there is the appearance that it will soon cease. He also says they have had few earthquakes at Hilo during the year, and these have been feeble. They are often felt near Kilauea, in the district of Kau.

Tortoises of Mauritius closely related to those of the Galapagos, places that are nearly antipodes to one another.—Dr. A. Günther, in a memoir on "The Living and Extinct Races of Gigantic Land-Tortoises," Parts I. and II. of which have been published, states that there are remains of gigantic tortoises on Mauritius and the neighbouring island of Rodriguez associated with those of the Dodo and Solitaire, which indicate that the races have only recently become extinct. They differ from other tortoises of the region in having a flat cranium and truncated beak, and in this respect they have the greatest affinity with the tortoises still inhabiting the Galapagos Archipelago. Dr. Günther observes that the presence of these allied tortoises at points so remote from one another can be accounted for only on the view that *they are in each case indigenous.*

Deposition in Salt Water more rapid than in Fresh Water.—Professor T. Sterry Hunt, in a recent article in the "Proceedings of the Boston Natural History Society," calls attention to the fact that the effect of salt in water on the rate of deposition was first mentioned by Mr. Slidell, in Humphrey and Abbott's "Report on the Mississippi River," and then explains it on the ground of the less cohesion between the particles of salt water, as proved by the fact that drops of salt water are smaller than those of fresh water.

Death of Sir Charles Lyell.—Since our last issue science has been deprived of, perhaps next to Mr. Darwin, its most devoted and most philosophic follower, in losing Sir Charles Lyell. The death of this most eminent savant, the father—since the time of Hutton—of geology, took place at his residence in Harley Street, on Feb. 22. Sir Charles was in his 78th year when he died, and it is not too much to say that from 1824, for quite fifty years, he was devoted to the pursuit of geological science. He contributed several papers to the especially scientific journals, but it is by his regular books that his vast reputation has been made. These are the "Principles of Geology" (2 vols.), "The Antiquity of Man," "The Elements of Geology," (2 vols.), and the "Students' Elements of Geology," of which the *first went through eleven editions*, the second went through four, and the third through six editions, thus showing how extremely large was their circulation. A capital sketch of his life is given in the "Geological Magazine," March 1875, to which we must refer our readers for further details.

Basaltic Sandstone.—"The Academy" (March 6), which is now becoming an exact and well-edited scientific, as well as a literary weekly, says, "that in some Notes from the Island of Bute, contributed to the 'Transactions of the Geological Society of Glasgow,' Mr. D. Corse Glen describes a narrow tract of sandstone remarkable for exhibiting a columnar structure, resembling that of certain basalts. The sandstone columns, which stand nearly vertical, vary in diameter from six inches down to half an inch, and although usually hexagonal, are in some cases four, eight, or ten-sided. There can be little doubt that this structure has been induced by the action of heat, but although igneous rocks are found in the neighbourhood it is not easy to determine precisely how they have affected the sandstone. Mr. Glen suggests that the effect has been due to the action of steam or highly-heated vapour passing through a vertical fissure in the rocks. Connected with the columnar sandstone of Bute, it may be interesting to remark that, at a recent meeting of the Imperial Geological Institution of Vienna, Dr. Hörnes brought forward a similar example in sandstone, obtained by Herr Baumheyer at Kriesdorf, in Bohemia. The sandstone appears to belong to the Lower Quadersandstein (Cretaceous), and the prismatic structure has evidently been induced by contact with basalt. In section the prisms are triangular, square, pentagonal, hexagonal, or seven-sided. Many other instances of a columnar structure in sedimentary rocks are mentioned by Dr. Hörnes."

Marsh's Miocene Expedition.—We learn from "Silliman's American Journal" (Feb. 1875), that Professor Marsh and his party have returned after an absence of two months in the West. The object of the present expedition was to examine a remarkable fossil locality, discovered during the

past summer in the "Bad Lands" south of the Black Hills. The explorations were very successful, notwithstanding extremely cold weather, and the continued hostility of the Sioux Indians. The latter refused to allow the expedition to cross the White River, but a reluctant consent was at last obtained. They afterwards stopped the party on the way to the "Bad Lands," attempted a night attack on their camp, and otherwise molested them, but the accompanying escort of United States troops proved sufficient for protection. The fossil deposits explored were mainly of Miocene age, and although quite limited in extent, proved to be rich beyond expectation. Nearly two tons of fossil bones were collected, most of them rare specimens, and many unknown to science. Among the most interesting remains found were several species of gigantic *Brontotheridæ*, nearly as large as elephants.

Professor Prestwich's Opening Lecture at Oxford.—We are happy to learn that Professor Prestwich's Oxford inaugural lecture was distinguished from the run of inaugural lectures by containing new and important geological views, and some account of the light that has been thrown on geology by Mr. Lockyer's spectroscopic researches. It is, we are informed, to be published immediately as a pamphlet.

Middle-Park "Mineral Coal."—Mr. E. J. Mallett, writing in a late number of an American journal ("The Rocky Mountain News"), says: "Considering all of its properties, I may say that it possesses much in common with the recently discovered mineral called *albertite*, a species of solidified petroleum, and also with what is known as *torbanite*. These two varieties are highly valued by gas manufacturers, who mix from five to twenty per cent. of these bituminous compounds with less bituminous coal, thereby greatly increasing the yield and quality of the gas. It resembles the former in the large amounts of gas and tarry oil it yields (which may prove as valuable as that derived from albertite), but differs from it in being heavier—the specific gravity of the albertite being 1·080, while this is 1·323—also in yielding no soluble products when treated with bisulphide of carbon, spirits of turpentine, ether, &c. From torbanite it differs in not crackling in the fire, in being much heavier, and in melting and intumescing when heated. Analysis shows it to contain in one hundred parts 6·02 per cent. of water and moisture, 39·95 per cent. of volatile matter (gas and tarry oil), 54·03 per cent. of fixed residue, consisting of coke and ash. As much confusion exists in the nomenclature of the mineral fuel of Colorado, I would propose, as I recently did to Professor Hayden, to give up entirely the term lignite as a special class name. If we call our mineral fuel lignite, we must conclude that lignite can be either bituminous caking, bituminous non-caking anthracite, or possess an organic structure. The term lignite should be dropped, as being inapplicable when applied to our mineral fuel as a class. The coal from Middle Park is of the class caking-bituminous, and being a peculiar variety, might be distinguished as "Byerite."

Vertebrate Fossils found in New Mexico.—Professor E. D. Cope, in a recent pamphlet, states that the Eocene discoveries shows that an Eocene lake extended over the part of New Mexico now drained by the tributaries of the Chama River on the east and the San Juan on the west. The

Mammalian remains differ from those of the Fort Bridger Eocene in the absence of species of the genus *Palæosyops*, and its replacement by *Bathmodon* (Cope), and by the presence of only one small *Hyrachyus*. Four new species of Toxodonts are among the discoveries reported; they are referred to the new genera *Ectoganus* and *Calamodon*. The teeth of six or seven species of sharks and one *Ostrea* have been found with the Mammalian remains.

The New Sub-Wealden boring is begun again. (The former one had failed through the breaking of one of the borers.) The "Academy," in one of its numbers for March, says: "A few weeks ago we referred to the action taken by the Sub-Wealden Exploration Committee in starting a new bore-hole at a short distance from the old site. Although it had been suggested that the second boring should be undertaken at some other locality, the Committee saw no reason for altering their original determination, and consequently the new hole was started on Feb. 11. The crown employed has a diameter of six inches, so that solid cores of nearly this size are now being extracted; and these large rock cylinders, when studied, will no doubt yield valuable geological information on the characters of the Sub-Wealden rocks.

New Order of Eocene Mammals.—At the last meeting of the Connecticut Academy, Feb. 17, Professor O. C. Marsh made a communication on a new order of Eocene Mammals, for which he proposed the name *Tillodontia*. These animals are among the most remarkable yet discovered in American strata, and seem to combine characters of several distinct groups, viz.: Carnivores, Ungulates, and Rodents. In *Tillotherium* (Marsh), the type of the order, the skull has the same general form as in the bears, but in its structure resembles that of Ungulates. The molar teeth are of the ungulate type, the canines are small, and in each jaw there is a pair of large scalpriform incisors faced with enamel, and growing from persistent pulps, as in Rodents. The adult dentition is as follows:—Incisors, $\frac{2}{2}$: canines, $\frac{1}{1}$: premolars, $\frac{3}{2}$; molars, $\frac{3}{3}$. The articulation of the lower jaw with the skull corresponds to that in Ungulates. The posterior nares open behind the last upper molars. The brain was small and somewhat convoluted. The skeleton most resembles that of Carnivores, especially the *Ursidæ*, but the scaphoid and lunar bones are not united, and there is a third trochanter on the femur. The radius and ulna, and the tibia and fibula, are distinct. The feet are plantigrade, and each had five digits, all terminated with long, compressed and pointed ungual phalanges, somewhat similar to those in the bears. The other genera of this order are less known, but all apparently had the same general characters. There are two distinct families, *Tillotheridæ*, in which the large incisors grew from persistent pulps, while the molars have roots; and the *Stylinodontidæ*, in which all the teeth are rootless. Some of the animals of this group were as large as a tapir. With *Hyrax* or the *Toxodontia* the present order appears to have no near affinities.—"Silliman's American Journal," March 1875.

MEDICAL SCIENCE.

Treatment of Catarrhal Jaundice by Electricity.—Dr. Gerhardt, of Berlin, first determines the position of the gall-bladder by percussion at the free border of the liver. This can often be detected by a small, rounded prominence at the inferior convexity of the liver, and can be easily made to project. The electrode of a strong inductive electric machine is applied at this point, while the other electrode is applied at the other side of the median abdominal line. Almost always, when the current is powerful, a gurgling sound can be heard, and very often the fæces resume their natural colour, and the cure is effected.

The Arctic Expedition.—The "Lancet" states that the proposed Arctic expedition, which will soon be an accomplished fact, will afford many opportunities of gaining useful knowledge on the important subject of sanitary science afloat. Although the records of most Arctic expeditions include some accounts of scurvy, we may fairly hope that the disease will find no place in the forthcoming exploration. But many valuable notes may be made as to diet, ventilation, clothing, and temperature, that might be turned to practical account by all engaged in looking after the health of seamen, whether in the royal or the merchant service.

The Comic Aspect of Cremation.—The following quotation is, according to an American cotemporary, from the London "Lancet:"—The question of burning the dead is exciting much discussion in California. One paper suggests some readings on plates of funeral urns in the future: "Charles Pupker, 3¼ lbs., cremated July 9, 1879. For wife of above see third pickle bottle on next shelf. Little Tommy, burnt up Sept. 16, 1881. Jane Matilda Perkins, Oct. 3, 1883. Put up by the Alden Corpse Cremating Company. None genuine without signature."

Tincture of Eucalyptus Globulus in Intermittent Fever.—The following results are summed up by Dr. Hirsch ("Berl. Klin. Wochenschrift," No. 30) as obtained from his experiments with the tincture in nine cases of obstinate intermittent fever: 1. In all the cases, after the use of the remedy for one or more days, the spleen diminished in size. 2. In six cases, three, at most four, teaspoonfuls of the medicine were sufficient to prevent a return of the paroxysms. In one case only was the double quantity required. 3. Seven of the nine cases were cured completely; in the remaining two the remedy proved unsuccessful. From these results Dr. H. draws the conclusion that tinct. eucalypt. glob. is a remedy but little, if any, inferior to quinine in the treatment of intermittent fever, and that it will probably prove to be as valuable an antiphlogistic in the treatment of other fevers as quinine, digitalis, and veratrum.

Prevention of Pitting in Small-pox.—Dr. Ward has found that the application of honey, painted on with a camel's-hair brush twice or thrice a day, prevents pitting in small-pox. He also recommends it for cracks in the skin from frost.

Cigars de Joy as a preventive of Asthma.—We thoroughly endorse what is said on this subject in the "Medical Record" (March 17). We believe

these cigars to be one of the very best preventives in asthma. The "Record" says: "The method of using is simple enough. They need only to be lighted and to be smoked as the Greeks are in the habit of smoking cigarettes of light Turkish tobacco, namely, by taking a deep sighing inspiration as each puff of smoke is drawn into the mouth. This sucks the medicated fumes into the air-tubes, and impregnates the air which passes into the lungs with the volatilised chemicals with which the cigarette-paper is impregnated. The local application of the medication has a very rapid effect in soothing bronchial irritation and relieving the spasms of air-tubes. One cigar at a time usually suffices. Many varieties of papers and cigars have been introduced since first the 'cigars de Joy' were brought into notice; but none of the more recent introductions have proved more generally useful than these; and thus, although they may have been partly lost sight of in the little crowd of new aspirants for favour, they are not less deserving of notice than ever, for they have lost none of their therapeutic merits."

How to Reduce extreme Fatness.—The "Practitioner" (Feb. 1875) gives the following means adopted by a French gentleman with the most satisfactory results:—"M. Philibert, at once an observer and a subject of this disease, at 26 years of age, weighed upwards of 340 lbs. and measured five feet round the waist. He consulted Dr. Schindler, and the following rules were laid down for him:—To rise at 6 A.M.; between 6.30 and 7, three glasses of Kreuzbrunn water; from 7.30 to 8, two eggs, a cup of tea, and a morsel of bread; from 9 to 10, vapour bath to sweating, followed by friction with a glove and a douche of cold water; vapour bath again to sweating, followed by friction with a soft brush; vapour bath again, and excitation of the skin by flagellation with a branch of poplar with leaves on, followed by cold douche. After leaving the bath, friction with vinegar; to take a walk after the bath. At 11 A.M., second breakfast, meat or fish, vegetables (haricot beans), half a bottle of wine, with a morsel of bread. From 12 to 6, steady and severe walking exercise, short of fatigue. At 6 P.M., dinner, cold meat, a *compote*, half a bottle of wine, and a little bread. After dinner, another walk. At 8 A.M., friction with soap. At 8.30, bed, with cold compress to belly for a time; also five pills containing alkaline bases. This treatment was well supported for five weeks with steady improvement, exercise being more easily borne, and sleep required less. The thirst, which at first was excessive, diminished. Loss of weight in six weeks, 35 lbs. M. Philibert then went to Marienbad, and then to Fontainebleau, where he tried the raisin cure. At neither of these places did he take any vegetable (legume) or raw fruit. In four months his weight had fallen to 260 lbs., and as the improvement continued, he now, five years after commencement of treatment, weighs only 190 lbs., and his general health is excellent."

METALLURGY, MINERALOGY, AND MINING.

Crystals of Fayalite from a Furnace Cinder.—At one of the meetings of the Manchester Philosophical Society, Mr. William H. Johnson, B.Sc., showed two remarkable pieces of iron cinder from a furnace in which iron is re-heated. The samples showed on one side small dark prismatic crystals, which appeared to have been formed in a cavity of the cinder as it cooled in the cinder bogie. The reverse side of one of them had formed the wall of a second cavity; its surface was, however, smooth, black, shining, and studded all over with the sides of oblong jet-black crystals unusually iridescent. He remarked that probably these crystals were fayalite, an iron chrysolite, a mineral found in the Mourne Mountains in Ireland, which is sometimes iridescent, and whose chemical composition is represented by the formula Fe_2SiO_4. They are the more worthy of notice from the rare occurrence of crystals in mill-furnace cinder.

Ludwigit, a New Mineral from Banat.—According to a paper by Herr G. Tschermak, in a late number of Liebig's "Annalen der Chémie," specimens of this mineral have been recently brought from Morawitza. It consists of fine, generally parallel fibres, whence recent specimens have a silky lustre. The colour is blackish-green, but there is a modification almost black with a violet cast. It is very tough, and the fibres are not easily separated from each other. They are sometimes 8 centimètres in length. The mineral is accompanied by magnetite in the shape of small grains, which intersect the mass in threads and veins. Granules of calcite are also met with. In hardness the mineral is equal to apatite. Its sp. gr. ranges from 3·907 to 4·016. The streak is blackish-green, but paler than the mass. The finest fragments, when examined under a power of 200 diameters, are transparent, with a greenish-brown colour. Its composition is—

Boracic acid	16·09
Oxide of iron	39·92
Protoxide of iron	12·46
Magnesia	31·69
	100·16

A new Mineral—Livingstonite.—This mineral, recently described by Senor M. Bárcena (see "Silliman's American Journal," last vol. p. 145), has been analysed by its describer with the following results: Sulphur 29·08, antimony 53·12, mercury 14·00, iron 3·50 = 99·70; whence the automic ratio for the sulphur, antimony, mercury and iron 18·17 : 8·7 : 1·4 : 1·2 = (nearly) 15 : 7 : 1 : 1. The livingstonite occurs at Huitzuco, in the State of Guerrero, in a matrix of carbonate and sulphate of lime, along with native sulphur, cinnabar, valentinite and stibnite. The author mentions the occurrence of some specimens of cinnabar at the locality which have the form of livingstonite, and which, therefore, are pseudomorphous.

What is Koppite?—We learn from a recent number of the "Academy" that, under the name of *Koppite*, Professor Knop of Carlsruhe, has published the preliminary description of a new mineral from the Kaiserstuhl, which

he dedicates to Hofrath Kopp, of Heidelberg. Mistaken hitherto for pyrochlore, it turns out to be a niobate of various metals, including calcium, cerium, lanthanum, didymium, potassium, &c.: a part of the oxygen in the compound being replaced by fluorine.

Mines of Pyrites of Wigsnoes, Norway.—The "Chemical News" of Jan. 8, 1875, gives the following note from a recent paper by M. F. Kuhlmann, jun.:—"The Wigsnces mine is situate in the island of Karmo, on the west coast of the Scandinavian peninsula. It was discovered in 1865 by a French engineer, M. Defrance. The beds of pyrites are in contact with metamorphotic schist on one side, and on the other with *gabro*, known as hyperite and euphotide, composed of a granular mass of labradorite, white, green, and violet, strongly impregnated with smarage and diallage. It contains rock crystal, titaniferous iron, and garnets. The ore is generally composed of sulphuret of iron mixed with sulphuret of copper and furrowed with blende. The gangue is silica, with a little flour spar and chlorite. Traces of carbonate of lime are also found. The average proportion of sulphur is 45 per cent., with 3 per cent of copper, though certain parts contain 12 to 14 per cent. of that metal. Specimens of metallic copper are also found. Silver and gold occur only in very small quantities. Of arsenic there is not a trace, which greatly enhances the value of the ore for the manufacture of sulphuric acid."

METEOROLOGY.

Weather Charts.—The Signal Office of the United States has sent over for distribution in this country a number of copies of the volumes containing the reduced daily charts, with the "Probabilities" and results for the months of October and November, 1872. The magnificence, says the "Academy," March 6, 1875, of the outlay on one science at the other side of the Atlantic makes us Europeans a little envious, as it is only with difficulty that Captain Hoffmeyer can procure a sufficiency of subscribers to guarantee himself against serious loss in his issue of daily synoptic charts of the weather of Europe: no European government dreams that such an object merits official pecuniary support. In this connexion we may remark that Captain Hoffmeyer announces that the future issue of his charts (see our issue of January 16) will be on a conical instead of "Mercator's" projection, and will therefore embrace a far larger extent of the earth's surface in high latitudes. Furthermore, they will contain some information as to temperature, all which changes will be recognised as desirable improvements by many of the supporters of the undertaking.

Meteorology in its Relation to Geography.—The progress of this branch of science has been well mapped out in a recent essay on the subject. Dr. Hann, who has paid more attention to the investigation of the climate of distant regions, especially in the southern hemisphere, than anyone else, has begun the laudable practice of publishing a yearly Report on the Progress of Geographical Meteorology. The first report, which appeared last year in the third volume of Behm's "Geographisches Jahrbuch" (Gotha: Perthes), consisted mainly of a summary of the different existing meteoro-

logical organisations on the globe. The present, being the second report, contains in forty-five pages a careful summary of all the important contributions to this branch of the science which appeared in the years 1872–3. We have not space even to hint at the principal works which are mentioned. One, however, of special interest to Londoners, is by Dove, on the results of a comparison of the temperatures obtained during twenty-nine years at Chiswick and at Greenwich, which shows that these two stations give very concordant results for the abnormal variations of temperature; but that as regards the mean temperature, taken on the average of nearly fifty years, there are noticeable differences, tending to indicate how unsafe it is to reason about the change of climate of large cities from the comparison of ancient with modern theometric records, taken probably under very different circumstances.

Dust from the Heavenly Bodies.—"Silliman's American Journal" for February 1875 contains a very interesting note of Nordenskiöld's on the above subject. He describes that found on the ice in several parts of Greenland, and he says of it that this material has much resemblance to the remarkable dust found by him scattered on the surface of the ice in the interior of Greenland, at a distance of thirty miles from the coast, and to which he gave the name *cryoconite.* This consisted for the most part of minute angular crystalline grains, which were colourless and transparent, with fragments possibly of feldspar and augite crystals, and some black magnetic particles. In an analysis the cryocinite was proved to consist of silica, alumina, oxide of iron, manganese, magnesia, potash, soda, with traces of chlorine and organic matter, and to give the oxygen ratio for the protoxyds, alumina, silica and water, 2 : 3 : 14 : 1. Its specific gravity is 2·63, and the crystalline form is monoclinic. He shows that the cryoconite must have had either a cosmical origin, or have come from Jan Mayen, or else some unknown volcanic region in the interior of Greenland, while the presence of cobalt, and probably nickel, would seem to prove that a part of the dust at least had a cosmical origin. He finally comes to this conclusion—that small quantities of a cosmical dust, containing metallic iron, cobalt, nickel, and phosphoric acid, and also a carbonaceous organic matter, falls upon the earth along with atmospheric precipitation.

MICROSCOPY.

How to Stain Thin Leaves or Green Sections for the Microscope.—Dr. C. Johnston adopts the method described below, which he has given in an essay on the subject in the "Monthly Microscopical Journal:"—"Colour must first be removed, or else staining would be of little service. The bleaching is to be accomplished through the agency of Labarraque's solution of chlorinated soda, in which the objects ought to be macerated, and suffered to remain until perfectly achromatic and transparent. Immediately thereafter others must be transferred to distilled water for an hour or two, and then to a 3 per cent. solution of oxalic acid in 50 per cent. alcohol, which neutralises the soda and disposes the tissue to accept the

aniline dye. At the operator's pleasure, the chlorinated leaves may be soaked in pure water for an hour, and afterwards in a 3 per cent. aqueous solution of alum, in preparation for the *logwood* staining. If the *aniline* blue dye be chosen, let the acidulated leaves be immersed in the blue fluid, and soaked for twenty or thirty minutes. Upon being withdrawn their colour will be found to be very intense, but washing in 90 per cent. alcohol for half a minute will remove superfluous aniline, and a final bath in absolute alcohol will in a few minutes prepare the object for being soaked in oil of cloves. With a bent platinum spatula the transparent preparations must be laid upon a slide, receive a liberal quantity of a solution of old balsam in chloroform poured upon it, and be covered with thin glass, on which a small weight is to be placed. In the course of a month or two the excess of balsam may be cleaned off, but the slide should bear a provisional label before the specimen is mounted."

The Examination of Blood-corpuscles.—The ordinary method of soaking out the shrivelled and distorted cells from a dried blood stain or clot, and then measuring their diameter under a suitably high power, is conceded to be satisfactory in many of the most frequently occurring cases (for instance, Dr. J. G. Richardson, U.S.A., who has been for several years a prominent advocate of the reliability of this method of distinguishing human blood, under high powers from that of certain domestic animals, has recently shown by numereus experiments the feasibility of thus distinguishing the blood of man, ox, and sheep); but it fails when the corpuscles approach each other too nearly in size. It also (says the "American Naturalist," February) gives unsatisfactory results with the oval nucleated corpuscles of reptiles, &c., which, when swelled by soaking, do not arrive at their original condition. Dr. R. M. Bertolet, of the Philadelphia Hospital, is represented as advising the following method of staining these corpuscles, which is applying one of the chemical tests for blood in a new way and with great precision. The blood is moistened with slightly acidulated glycerine, and then carefully irrigated with an alcoholic solution of guiacum resin, and finally a small quantity of ethereal solution of ozonic ether (peroxide of hydrogen) is flowed beneath the cover. By this procedure the whole corpuscle is stained of a uniform colour, which varies in different corpuscles from a light sapphire to a deep blue, except in case of the nucleated corpuscles in which the nucleus assume a distinctly different tint from the rest.

American Opinion of Ross's Microscopes.—We had imagined that the "American Naturalist" had extremely American prejudices, but it seems we are entirely mistaken, as the following observatious, taken from its number for February 1875, will show:—"The adoption by this great house of the Jackson model of stand (which has long been very generally preferred in this country, if not everywhere), in place of the transverse bar model which had come to be familiarly known as the Ross style, is an innovation of sufficient importance to attract special notice, and, we may add, congratulation. The magnificent workmanship of the old Ross stand is no secret, and is a sufficient assurance of the mechanical excellence of the new ones, while the fact that they are designed by Mr. Wenham leaves nothing to be said as to their microscopical efficiency. The new stands, while adhering substantially to the Jackson model, combine some of the

best features of the previous stands of Ross, Powell & Lealand, Ladd, and other makers. The Ross new patent object-glasses (devised by Mr. Wenham) are believed by the makers to have so well proved their superiority that they are now exclusively offered, and the old construction abandoned, from the half inch upwards."

Microscopical Papers of the Quarter.—The following papers have been published in the "Monthly Microscopical Journal" for January, February, and March, 1875:—

On the Development of the Smaller Blood-vessels in the Human Embryo. By Dr. H. D. Schmidt, of New Orleans, U.S.A.—On Pigment-Flakes, Pigmentary Particles, and Pigment-Scales. By Joseph G. Richardson, M.D., Microscopist to the Pennsylvania Hospital.—On a Modification of the "Slit" for Testing Angle. By R. B. Tolles, Boston, U.S.A.—On Some Male Rotifers. By C. T. Hudson, LL.D.—On the Invisibility of Minute Refracting Bodies caused by Excess of Aperture, and upon the Development of Black Aperture Test-bands and Diffraction Rings. By Dr. Royston-Piggott, M.A., F.R.S., &c.—On Bog Mosses. By R. Braithwaite, M.D., F.L.S., &c.—On the Similarity between the Red Blood-corpuscles of Man and those of certain other Mammals, especially the Dog: considered in connection with the Diagnosis of Blood Stains in Criminal Cases. By Dr. J. J. Woodward, U.S. Army.—A New Illuminating Apparatus for the Microscope. By Professor E. Abbe, of Jena.—The President's Address to the Royal Microscopical Society.—Studies in the Natural History of the Urates. By W. M. Ord, M.B. Lond., Senior Assistant-Physician to St. Thomas's Hospital.—Certain Fungi Parasitic on Plants. By Thomas Taylor, Microscopist of the United States' Department of Agriculture, Washington, D.C., U.S.A.

PHYSICS.

A New Instrument for Multiplying Small Motions.—This is the subject of a paper which was lately read before the Physical Society by Mr. G. F. Redwell. The instrument consists of a train of multiplying wheels, the first of which is moved by the body whose elongation is to be determined, while the teeth of the last engage with the threads of an endless screw, whose axis is vertical, and carries at its upper extremity a long index moving over a graduated circle.

Apparatus for showing Internal Resistance in Battery Cells.—Professor Macleod read a paper on this subject before the Physical Society. Two tubes about half a mètre long, and one of which is twice the diameter of the other, are closed at their lower ends with corks. On the corks and within the tubes rest two discs of platinum foil, connected with binding-screws by platinum wires passing through the corks. The platinum plates are covered with small quantities of chloride of silver, and the tubes are filled with a solution of chloride of zinc. Each tube is provided with a disc of amalgamated zinc soldered to a long copper wire, which is well

covered by an insulating material. The discs are cut so that they nearly fit the tubes, one being exactly double the diameter of the other, and therefore exposing four times the surface to the action of the liquid. On connecting the terminals with a galvanometer, the current will be found to increase as the distance between the zinc and platinum plates is diminished by lowering the zinc plate in the tube. In order to obtain the same deflection of the galvanometer by the narrow cell, the distance between the plates must be one-fourth of the distance between those of the larger one.

Index of Refraction of Liquids.—MM. Terquem and Trannin propose a new method of determining the index of refraction of liquids, based on total reflection. A small tank with parallel sides of glass is used to contain the liquid. In this are placed two plates of glass cemented along the edges, and free to turn through a measurable angle. The whole is placed between the collimator and observing telescope of an optical circle. The image of the slit being distinctly seen, the plates are turned until total reflection takes place, when the slit disappears. Then turning the plates in the opposite direction, a second measurement is obtained, and the difference equals twice the limiting angle of the liquid with regard to air. With common light the image turns red before disappearing, but with monochromatic light the disappearance is almost instantaneous, and can be determined within a quarter of a minute. With a Geissler tube containing hydrogen as a source of light, the image undergoes two marked changes of colour, due to the total reflection of the two rays $H\gamma$ and $H\beta$. The error then is only about half a minute, and for $H\alpha$ about a quarter of a minute. The measurements of several liquids are given, agreeing very closely with previous determinations, the difference being readily accounted for by the difficulty of obtaining the liquid perfectly pure.—See also "Comptes Rendus," lxviii. p. 1843.

Expansion of Hard Rubber.—Having several times noticed that glass flasks, closed by stoppers of hard rubber, burst, M. Kohlrausch concluded that this substance must be very dilatable. This hypothesis was fully verified by experiment, for the expansion of this body was found to be about three times that of zinc. From his measures, the coefficient of dilatation for 1° between 16°·7 and 25°·3 = ·0000770, and between 25°·3 and 35°·4 = ·0000842. Thus, not only has hard rubber a very great coefficient of dilatation, but the latter increases very rapidly with the temperature. This remarkable property can be applied to the construction of very delicate thermometers. Thus, with a small instrument, consisting of two strips of rubber and ivory, 20 cms. long, glued together and fastened at one end, we obtain, at the other extremity, a movement of several millimètres for a change of temperature of one degree. The coefficient of hard rubber is equal, at zero, to that of mercury: above, it is greater. We can, then, as a curiosity, construct a mercury thermometer with a reservoir of this substance, whose changes will be the opposite of those of a common thermometer, and which will fall with an increase of temperature.

Singing Flames and Sympathetic Vibrations.—M. E. Gripon has studied at length the influence exercised on the vibrations of a column of air by neighboring sonorous bodies. He concludes that the pitch of a vibrating mass of air is raised by bringing near its orifice an elastic membrane or a second mass of air which alone would give the same note. A similar effect is pro-

duced, but in a less marked manner, if the second mass of air or membrane has a higher pitch than the first. The pitch of a membrane, on the other hand, is lowered by bringing a solid body near it. In order that a layer of air, bounded on one side by a membrane and on the other by a plane parallel to it formed by a solid free around its edge, may be reinforced by a given sound, its thickness must be proportional to its length; further, this thickness depends on the ratio which exists between the sound proper to the membrane and the given sound, and also on the nature and dimensions of the membrane. We can, with sounding tubes with flute embouchure, reproduce the principal phenomena obtained with singing flames. The pitch of a pipe falls when we bring a solid body near its orifice. This flattening is still produced when the pipe is the centre of a solid plane which extends indefinitely around the pipe.

Electrical Polarisation.—A great number of experiments on the electrical currents accompanying the non-simultaneous immersion of two mercury electrodes in various liquids are described in detail by M. G. Quincke, who has arrived at the following conclusions: If two mercury electrodes, connected by the wire of a multiplier, be immersed one after the other in any liquid which is a conductor of electricity (water, alcohol, saline solutions, &c.), an electric current is observed passing from the freshly wetted mercury surface through the liquid to the other mercury surface. The strength of the current diminishes as the resistance of the liquid column between the electrodes is increased. The electromotive force varies with the nature of the liquid and increases as the concentration diminishes, in some cases amounting to 0·6 of a Volt. The electromotive force increases if the boundary surface of mercury with the surrounding liquid in the last immersed electrode is more quickly produced. It soon, however, reaches a maximum, especially in the case of viscous liquids like glycerine. The cause of these currents is probably the alteration in molecular condition (change of density or concentration), which is gradually accomplished in the liquid near the surface of contact after the wetting.

Curious Effect of Flame on an Electric Spark.—A curious effect of a gas flame on the current of a Holtz machine has been recently noticed by Mr. S. J. Mixter, and is recorded in "Silliman's American Journal" for January 1875. The jet consisted of a glass tube drawn out to a point, and the flame had a length of about an inch and a diameter of only an eighth of an inch. Inserting this between the two terminals of the machine, the length of spark obtainable was at once increased from less than ten inches to over twelve, the full distance to which the balls could be separated. The same increase was not obtained by simply inserting a conductor between the two terminals, a ball an inch in diameter only lengthening the spark about an inch.

Metallic Sulphides and their Electric conducting Power.—In a number of the "Academy" for March appears the following note on this subject:—Apropos of a paper which appeared recently in "Pogg. Ann.," and was noticed in the "Academy" (Jan. 30), on the behaviour of iron and steel bars in a galvanic circuit, M. F. Braun, in "Pogg. Ann." (cliii. p. 557), gives an account of certain curious phenomena connected with the passage of electric currents through natural and artificial metallic sulphides. The

paper is intended to be preliminary, the general conditions and difficulties of the experiments, and some of the results obtained, being only recorded. The galvanic resistance of the metallic sulphides examined, whether in the crystalline form or otherwise, was found to vary with the direction, strength, and duration of the current which passed through them.

Electrostatic Induction.—The "Comptes Rendus" (lxxix. p. 1071) contains a paper of interest on the above subject. M. Neyreneuf has repeated with a Holtz the experiments of MM. Verdet and Masson, to determine the direction of the induced current with the electric egg. Two Matteucci discs contain, one the inducing, the other the induced spiral. This latter is put in connection with the two extremities of a cylindrical Geissler tube 50 cms. long. The first spiral is connected by one end with the negative armature of the machine, while the other is attached to one plate of a condenser with air film, whose collector communicated with the positive armature. The spark leaps between the two armatures of the machine from which the condensers have been removed. Two currents in opposite directions traverse the inducing spiral under these conditions, the one to charge, the other to discharge the condenser. Those produced in the second spiral illuminate the Geissler tube very brilliantly. With an explosive distance of 5 cms. we observe clearly the difference in appearance of the two poles; but we can, by diminishing it continuously, produce three separate inversions at the instants when the appearance of the two poles is identical. When the striking distance is 3 cms. large and widely separated stratifications are formed, but presenting before the last inversion all the characters produced by a Ruhmkorff coil. The same effects are produced by altering the distance of the spirals or of the plates of the condenser. These condensers show that the phenomenon in question bears no relation to the lateral discharge, characterised especially by the constancy of the direction of the current it produces.

Does the Thermal Conductivity of Mercury vary with the Temperature?—The following important note appears in the "Academy" (March). The author remarks that the paper it refers to, which appears in the "Philosophical Magazine" for March, was originally communicated to "Poggendorff's Annalen." According to Wiedemann and Franz, the metals have equal conducting power for heat and electricity, and since we know from numerous experiments that for electric conductivity a very marked variability with the temperatures takes place, it follows, if the statement of Wiedemann and Franz be true, that there will be found for the thermal conductivity of most metals a variability with temperature in about the same degree. On the other hand Lorenz has asserted the independence of temperature of the heat-conductivity of pure metals which remain homogeneous, and accounted for the observed variations by assuming the development of thermo-electric currents in consequence of unequal heating of the metals. To decide this question it was necessary to employ a pure metal which remains homogeneous, and mercury was accordingly selected as being the only known metal satisfying the condition. Herwig's experiments show that between 40° and 160° C. the heat-conducting power of pure mercury is perfectly constant, and so far confirm the results of Lorenz. The author is occupied with the arrangement of experiments the object of which is to ascertain how far solid metals differ in their behaviour from mercury.

The Elasticity of Rods of Calcareous Spar.—In the "Chemical News" of Feb. 12, Herr G. Baumgarten gives an account of experiments undertaken to determine the elasticity of crystalline bodies, calcareous spars being selected for the sake of convenience. The results may be summed up as follows:—The bending of a rod is independent of the position of the lateral plane; it depends on dimensions in the same manner as in non-crystalline bodies, being directly proportional to the cube of the length, and indirectly proportional to the cubes of the breadth and thickness. There is no symmetry towards the principal axis. The minimum bending is in the direction of the corners, and the maximum in the short rhombus diagonal. It appears that all the planes of a rhombohedral primary form are tangents of the superficies of deflection along a curve. The deflections are not proportional to the weights, and the increase of the deflections becomes smaller when the weights are greater. It appears as if the linear differential equations of elasticity lost their validity in case of crystals.

On Specific Gravity.—In a late number of the "Proceedings of the Philadelphia Academy of Science," Professor Leidy remarks, that in taking the specific gravity of minerals by means of the scales in weighing the substance in water, the usual plan is to suspend it from one side of the instrument by a delicate thread or hair. The attachment of the specimen was tedious and often difficult, especially in the case of small crystals and polished gems, from which the hair would slip, and could only be made to retain its position by causing it to stick with some adhesive matter. He dispensed with the thread or hair, and substituted on one side of the balance a double dish. The lower dish is perforated, and is kept suspended in a glass of water. After weighing the specimen in air in the upper dish, it is simply necessary to change its place to the lower dish to weigh it in water.

Lights that are Useful in Photography.—In the "Comptes Rendus" (Jan. 25), MM. Riche and Bardy state that they have re-examined the bisulphide of carbon and nitric oxide light of Delachanal and Mermet, in the hope of finding means to obviate the danger of explosion, either by modifying the manner of operating, or by suppressing the use of sulphide of carbon, and of comparing the various flames which act upon the salts of silver. They recommend as the most efficacious, and as perfectly free from danger, the flame of sulphur burning in a jet of oxygen.

Electro-chemical Resistance of Aluminium.—The "Chemical News" of Feb. 26 says that M. E. Ducretet has recently been experimenting on this subject. It seems that a voltameter with acidulated water received a slip of platinum and a slip of aluminium, placed in communication with the poles of a battery; if the aluminium is the negative electrode, hydrogen is disengaged upon it, and the current has its ordinary intensity. When the direction of the current is reversed, there is no longer decomposition of water, and the intensity of the current becomes very feeble. The surface of the aluminium does not seem affected; it is preserved by a thin layer of alumina. The author applies these results to the construction of a liquid rheotome, permitting the passage of the current only in one direction.

ZOOLOGY AND COMPARATIVE ANATOMY.

The Skeleton of the Ostrich Group.—At a recent meeting of the Zoological Society of London, Professor Mivart, F.R.S., read a paper on the axial skeleton of the Struthionidæ, and pointed out that, judging by the characters of the axial skeleton, the Emeu presents the least differential type; from which *Rhea* diverges most on the one hand and *Apteryx* on the other: that the resemblance between *Dromæus* and *Casuarius* is exceedingly close, while the axial skeleton of *Dinornis* is intermediate between that of *Casuarius* and *Apteryx*; its affinities, however, with the existing New Zealand form very decidedly predominating.

The Measurement of Blood Corpuscles of Animals.—A communication was read before the Zoological Society of London, from Mr. George Gulliver, F.R.S., F.Z.S., containing measurements of the red corpuscles of the blood of *Hippopotamus amphibius*, *Otaria jubata*, and *Trichecus rosmarus*.

The Development of Marine Sponges is the subject of a couple of papers appearing in the "Annals of Natural History." They are from the pen of Mr. H. J. Carter, F.R.S., and give the results of his own observations, which were conducted from the time when the ovum first appears to the condition of adult sponge.

A Notice of a Paper on Embryology.—A capital notice is written in "Silliman's American Journal" for Dec. 1874, on the subject of Kowalevsky's recent [Russian] papers on Embryology. In one of these the author, it is said [by Mr. Agassiz, jun., who is the writer], "continues the investigations he had been carrying on regarding the existence of an ectoderm and entoderm layer in the early embryonic stages of Invertebrates. In the present paper he has given a summary of the early stages of a Campanularia, confirming the observations of Wright and A. Agassiz. For Rhizostoma and Cassiopea he shows that the digestive cavity is formed by the invagination of the ectoderm. This is contrary to the results of previous observers, except Schneider. For Pelagia he shows a direct development from the egg remarkably similar to that of the Geryonidæ as we know it from Hæckel, Fol, and Metschnikoff. He adds nothing to the embryology of Actinia not already known from the magnificent monograph of Lacaze-Duthiers. He then passes on to the development of Alcyonium, of which he gives an extremely interesting sketch, supplemented by fragments on the embryology of Astræa, Gorgonia, and Cerianthus: the development of the latter is strikingly similar to that of Edwardsia, as we know it during its passage from Arachnactis to Edwardsia. He has added a few observations on the earlier embryonic stages of Eschscholtzia, Beroë, and Eucharis, completing deficiencies in his earlier papers on the embryology of Ctenophoræ. These supplementary observations agree completely with the observations of A. Agassiz on the embryology of Ctenophoræ."

Some Peculiarities of Amphioxus.—In a most important and valuable paper which Professor Huxley read before the Linnean Society, on Dec. 4, 1874, there are some passages on the subject of the curious little fish, the Amphioxus, which are of interest. The Professor says:—"Amphioxus,

which so closely resembles an Ascidian in its development, has a perivisceral cavity which essentially corresponds with the atrium of the Ascidian, though it is formed in a somewhat different manner. One of the most striking peculiarities in the structure of Amphioxus is the fact that the body wall (which obviously answers to the somatopleure of one of the higher *Vertebrata*, and incloses a 'pleuro-peritoneal' cavity, in the walls of which the generative organs are developed) covers the branchial apertures, so that the latter open into the 'pleuro-peritoneal' cavity. This occurs in no other vertebrated animal. Kowalewsky has proved that this very exceptional structure results from the development of the somatopleure as a lamina which grows out from the sides of the body, and eventually becomes united with its fellow in the middle ventral line, leaving only the so-called 'respiratory pore' open. Stieda has mentioned the existence of the raphé in the position of the line of union in the adult animal. Rathke described two 'abdominal canals' in Amphioxus; and Johannes Müller, and more recently Stieda, have described and figured these canals. However, Rathke's canals have no existence, and what have been taken for them are simply passages or semi-canals between the proper ventral wall of the abdomen and the incurved edges of two ridges developed at the junction of the ventral with the lateral faces of the body, which extend from behind the abdominal pore where they nearly meet, to the sides of the mouth. Doubtless, the ova which Kowalewsky saw pass out of the mouth had entered into these semi-canals when they left the body by the abdominal pore, and were conveyed by them to the oral region. The ventral integument, between the ventro-lateral laminæ, is folded, as Stieda has indicated, into numerous close-set, longitudinal plaits, which have been mistaken for muscular fibres, and the grooves between these plaits are occupied by epidermic cells, so that, in transverse section, the interspaces between the plaits have the appearance of glandular cœca. This plaited organ appears to represent the Wolffian duct of the higher Vertebrata, which, in accordance with the generally embryonic character of Amphioxus, retains its primitive form of an open groove. The somatopleure of Amphioxus, therefore, resembles that of ordinary Vertebrata in giving rise to a Wolffian duct by invagination of its inner surface. But the Wolffian duct does not become converted into a tube, and its dorsal or axial wall unites with its fellow in the raphé of the ventral boundary of the perivisceral cavity."

The true Position of the Sponges is, as pointed out by Mr. A. S. Packard in the "American Naturalist" (Feb. 1875), between the Cœlenterata and the Protozoa. The embryo sponge arises from eggs which undergo a total segmentation of the yolk. The free swimming larva later in its life becomes fixed, loses its external cilia, but retains its cellular walls, now composed of two layers, which are supported by silicious or calcareous needles or spicules developed in the inner layer. To regard such an organism as a Protozoan, or even to compare it with a compound Radiolarian such as Sphærozoum, with its silicious spicules and aggregations of one-celled organisms, would not seem warranted. We have, in fact, in the light of the anatomical investigations of Lieberkühn, Carter and Clark, and the combined anatomical and embryological studies of Hæckel, Metschnikoff, and Carter, no grounds for leaving them among the Protozoa. Indeed, one

of the most striking illustrations of the value of the knowledge of the early history of an organism is afforded by the embryology of the sponge. Hæckel's discovery that the larva sponge is a planula, though not homologous with the embryo polype or jelly-fish, enables the naturalist to at once decide that the sponge is not a Protozoan, but belongs to a type only less highly organised than the lower polypes, and with more analogy to the Radiates than the Protozoa. If, under the guidance of the results of the studies of Lieberkühn, Carter, Clark, and particularly of Hæckel and Metschnikoff, we examine the structure of a sponge, we shall find that in its simplest form it is a hollow, vertical cylinder, fastened by its base, with the mouth opening upwards from a central gastro-vascular cavity, with ciliated epithelial cells lining the cavity, and possessing a surprising degree of individuality. There usually are several mouths, and the cavity usually opens into a labyrinth of chambers connected by passages through the cellular tissue; these round chambers being lined with ciliated epithelial cells. This body is supported by a basket-work of interlaced needles of silica or lime, developed in the inner layer of cells of the larva. Such, in brief, is the sponge. Does the fact that in the simplest, immature forms, we have quite a regular body-wall and a single cavity, compel us to range the sponges side by side, and in the same natural division with the polypes and jelly-fishes, in the typical forms of which the central cavity acts as a mouth? Metschnikoff has shown that it would seem to be a violation of the existing principles of classification to place together animals so unlike. The sponges apparently represent a class lower than, but possibly equivalent, systematically, to the polypes and jelly-fishes.

Professor Huxley's Classification of the Animal Kingdom.—In a paper which he read before the Linnean Society in December last, and which was for a time withdrawn, so that we had not the opportunity of laying its result before our readers in the last number, Professor Huxley makes the following remarks:—"Animals are primarily divisible into those in which the body is not differentiated into histogenetic cells (Protozoa), and those in which the body becomes differentiated into such cells (Metazoa of Hæckel). I. The Protozoa are again divisible into two groups: 1, the Monera (Hæckel), in which the body contains no nucleus; and 2, the Endoplastica, in which the body contains one or more nuclei. Among these the Infusoria, Ciliata, and Flagellata (*e.g.* Noctiluca), while not forsaking the general type of the single cell, attain a considerable complexity of organisation, presenting a parallel to what happens among the unicellular Fungi and Algæ (*e.g.* Mucor, Vaucheria, Caulerpa). II. The Metazoa are distinguishable, in the first place, into those which develop an alimentary cavity—a process which is accompanied by the differentiation of the body-wall into, at fewest, two layers, an epiblast and a hypoblast (*Gastræa* of Hæckel), and those in which no alimentary cavity is ever formed. Among the Gastræœ there are some in which the gastrula, or primitive sac with a double wall open at one end, retains this primitive opening throughout life as the egestive aperture; numerous ingestive apertures being developed in the lateral walls of the gastrula—whence these may be termed Polystomata. This group comprehends the Spongida or Porifera. All other Gastræœ are Monostomata, that is to say the gastrula develops but one

ingestive aperture. The case of compound organisms in which new gastrulæ are produced by germination is of course not a real exception to this rule. In some Monostomata the primitive aperture becomes the permanent mouth of the animal (Archæstomata). This division includes two groups, the members of each of which are very closely allied:—1. The Cœlenterata. 2. The Scolecimorpha. Under the latter head are included the Turbellaria, the Nematoidea, the Trematoda, the Hirudinea, the Oligochæta, and probably the Rotifera and Gephyrea. In all the other Monostomata the primitive opening of the gastrula, whatever its fate, does not become the mouth, but the latter is produced by a secondary perforation of the body wall. In these Deuterostomata there is a perivisceral cavity distinct from the alimentary canal, but this perivisceral cavity is produced in different ways. [The paper is of much greater length, but we have not further space for it, and to make an abstract would be impossible, so condensed is its style.]

Notice to North-American Zoologists.—It seems that the journal called "Pysche," published by the Cambridge (U.S.A.) Entomological Club, has met with such a favourable reception on all sides, that its continuance in its present form is assured, but it is found impossible within the limits of four pages each month to bring up to date the *Bibliographical Record of North-American Entomology*, indispensable to every entomologist. The members of the Club have therefore doubled the numbers for January and February, and have decided to make this enlargement permanent, if sufficient support was guaranteed before March 1, 1875. To accomplish this, at least eighty new subscribers are needed. "Psyche" will contain such parts of the proceedings of the Cambridge Entomological Club as are of general interest, contributions upon the habits of insects, lists of captures, and a record of all writings upon entomology published in North America, and of all foreign writings upon North-American insects since the beginning of 1874, with a brief note on the contents of each.

The largest Cuttle-fish ever captured.—Professor A. E. Verril, in an article on the subject of recently-captured cuttle-fish, says: "The most complete specimen that has ever come under scientific observation was captured in November 1873, at Logie Bay, near St. John's, Newfoundland. It became entangled in herring-nets and was secured by the fishermen with some difficulty, and only after quite a struggle, during which its head was badly mutilated and severed from the body, and the eyes, most of the siphon-tube, and the front edge of the mantle, were destroyed. Fortunately this specimen was secured by the Rev. M. Harvey of St. John's. After it had been photographed and measured, he attempted to preserve it entire in brine, but this was found to be ineffectual; and after decomposition had begun to destroy some of the most perishable parts, he took it from the brine and, dividing it into several portions, preserved such parts as were still undecomposed in strong alcohol. These various portions are now in my possession, and with the photographs have enabled me to present a restoration, believed to be quite accurate, of the entire creature. In this figure the eyes, ears, siphon-tube, and front edge of the mantle have been restored from a small squid (*Loligo pallida*), to which this gigantic species seems to be nearly allied in many respects. It seems to measure over eleven feet in length.—*Silliman's American Journal*, Feb. 1875.

Death of Dr. J. E. Gray, the eminent Naturalist.—On March 7 Dr. Gray passed away from us, in the 74th year of his age. The "Academy" (March 13) gives the following account of his labours:—"John Edward Gray, the son of Mr. F. S. Gray, of Walsall, was born in 1800, and educated for the medical profession. At the age of twenty-one he published his "Natural Arrangement of British Plants," a work which has the merit of being an early attempt to introduce the natural system to the notice of British botanists. Three years later he entered the Natural History Department of the British Museum, and rose in 1840 to the rank of Keeper. A fine series of catalogues of the collections has been issued under his care, many of the departments having been described by himself: thus, only a few months ago he brought out his 'Hand-List of Seals, Morses, Sea-Lions, and Sea-Bears.' But in addition to these official publications, and to the large number of his communications to learned societies and scientific serials, he found time to write such works as 'A Manual of British Land and Fresh-Water Shells,' 'Illustrations of Indian Zoology,' and 'The Knowsley Menagerie.' Years of concentration upon the minute shades of difference necessary for the identification of species scarcely tend to broaden a man's views; but it should not be forgotten that Dr. Gray, in addition to his labours as a systematic zoologist, exercised himself in the discussion of wide questions of social importance."

The Large Human Fluke: Distoma Crassum.—Dr. Spencer Cobbold read a paper on this subject before the Linnean Society at its meeting on Feb. 18, 1875. After some details, stating the source from whence he obtained the specimens and the previously recorded history of this parasite, the author stated that he found the vitelligene glands to be largely developed: and he believed that in place of there being two testes, as had hitherto been conjectured, there was only one large compound gland, whose seminal ducts are remarkably large and conspicuous. The ducts were well seen in the dried specimens exhibited to the Society. The hitherto supposed upper testis turned out to be the ovary, and there was a special and smaller organ in front of the ovary, which he regarded as an unusually developed shell-gland. The intestinal tubes are simple and unbranched; but, on the other hand, the uterine organ appeared not to consist of a single continuous tube, but to be partly branched, as obtains in *D. lanceolatum* and in some other less-known flukes. The remainder of the communication was taken up with remarks on the affinities of the parasite, and with a brief *résumé* of the hitherto known facts of trematode development, in so far as they tended to throw light upon the source of *Distoma crassum*. From a general review of all the data thus obtained, Dr. Cobbold believed that the *Distoma crassum* had been obtained by the consumption, on the part of the sufferer, either of Ningpo oysters or of fish insufficiently cooked.

The Flea gregariously Parasitic.—At a meeting of the Entomological Society, on Feb. 15, Mr. Verrall exhibited some living fleas taken two days previously from inside the ears of a rabbit near Lewes. They were gregarious in this situation, and in such a position that the animal was unable to dislodge them by scratching. He alluded to a communication made to him by Mr. M'Lachlan regarding a species from Ceylon which was gregariously collected in a very limited space on the neck of a fowl, and

which had been exhibited at a recent meeting of the Microscopical Society. They were affixed to the skin of the fowl by the proboscis, so that only the tails were visible outwards.

Embryology of the Ctenophoræ.—The development of certain jelly-fishes (Ctenophoræ) belonging to the genera Idyia and Pleurobrachia has been elaborated with great care and beauty of illustration by Mr. A. Agassiz, in a memoir which has been recently published in the United States of America. He gives, says the "American Naturalist" for January, a connected account of their history from the earliest stages in the egg until all the features of the adult appear. While the mode of segmentation of the yolk is extraordinary, the embryo attains the adult form without any metamorphosis, the changes being very gradual. Mr. Agassiz's observations, with the preceding ones of Müller, Gegenbaur, Kowalevsky, and Fol, give us a tolerably complete view of the mode of development of this order of jelly-fishes. These Ctenophoræ on our coast spawn late in the summer and fall. The young brood developed in the autumn comes to the surface the following spring nearly full-grown, to lay their eggs late in the summer. The autumn brood most probably passes the whole winter in deep water, and it must take six to eight months for the young to attain their maturity.

Plate XXII

FIG. 1

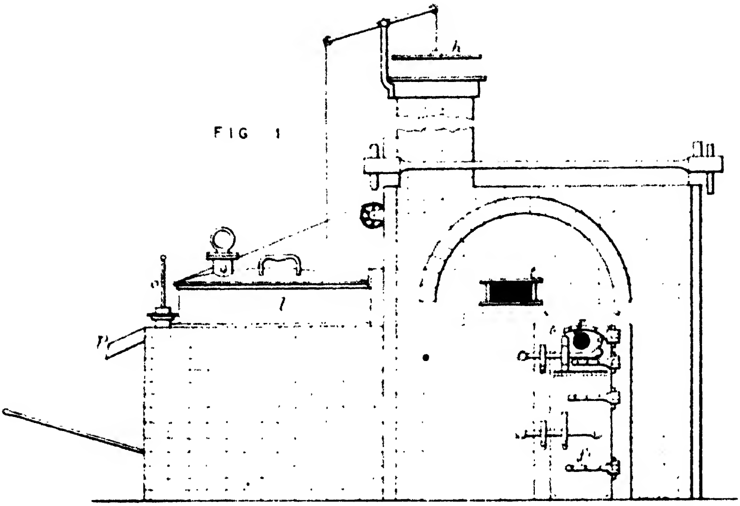


FIG. 2

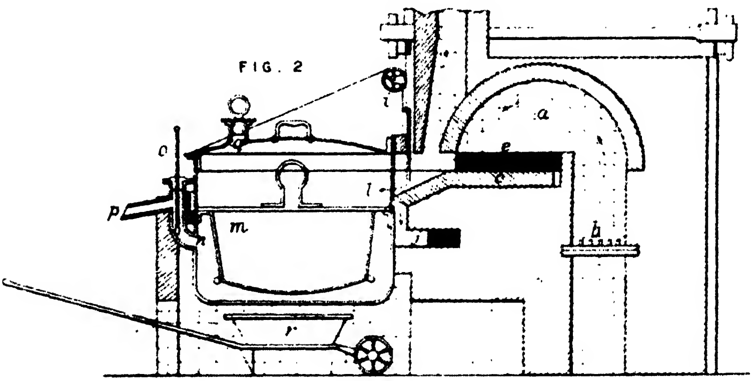
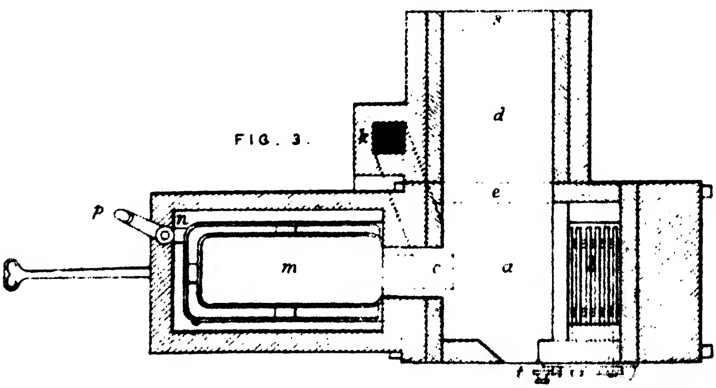


FIG. 3.



W. West & Co. sc.

UNBREAKABLE OR TOUGHENED GLASS: A NOVEL MODE OF MANUFACTURE.

By PERRY F. NURSEY, C.E.

[PLATE CXXII.]

A CONSIDERABLE degree of well-merited attention has of late been directed towards an invention which may be justly termed remarkable, even in these days of startling discoveries, inasmuch as it is one which promises to effect a complete change in the physical character of glass. This invention is the toughening process of M. François Royer de la Bastie, by which the natural brittleness of ordinary glass is exchanged for a condition of extreme toughness and durability. And this invention is perhaps the more remarkable in that it does not emanate from one engaged in, or practically conversant with, the manufacture of glass, nor is the discovery due to one of the great lights of science of our day; neither was it the result of a happy momentary inspiration. On the contrary, M. de la Bastie is a French private gentleman of fortune, residing in his native country, who, however, is given to the study of scientific matters. He was educated as an engineer, but his position and means rendered it unnecessary for him to follow the profession into which he had been initiated. He, however, is fond of experimenting in matters relating to engineering, and amongst other things he, some years since, conceived the idea of rendering glass less susceptible to fracture, either from blows or from rapid alternations of heat and cold. The early training of his mind naturally led him to look to mechanical means for the accomplishment of this end; and he, in the first place, set himself a purely mechanical problem to solve. He thought—as did Sir Joseph Whitworth with regard to steel—that by submitting glass when in a soft or fluid condition to great compressive power, he should force its molecules closer together, and, by thus rendering the mass more compact, the strength and solidity of the material would be greatly increased. This was not an unreasonable line of argument, inasmuch as the

fragility of glass results from the weakness of the cohesion of its molecules. Success, however, did not follow experiment, and the mechanical problem was laid aside unsolved.

M. de la Bastie, however, continued to regard the question from an engineering point of view, and turned his attention to another method of treatment. Aware that the tenacity of steel was increased, and that a considerable degree of toughness was imparted to it by dipping it, while hot, into heated oil, he experimented with glass in a similar manner. The results were sufficiently successful to encourage him to persevere in this direction, and, by degrees, to add other fatty constituents to the oil bath. Improved results were the consequence; and they continued to improve until at length, after several years of patient research and experiment, De la Bastie succeeded—with a bath consisting of a mixture of oils, wax, tallow, resin, and other similar ingredients—in producing a number of samples of glass which were practically unbreakable. As may be supposed, there were other conditions upon which success depended besides the character and proportions of the ingredients constituting the bath. M. de la Bastie, not being a glass manufacturer, purchased sheets of glass, as well as glass articles, which he heated in a furnace or oven, to a certain temperature, and transferred to the oleaginous bath, which was also heated to a given temperature. These questions of relative temperature, therefore, had to be worked out; and De la Bastie had further to determine, very precisely, the condition of the glass most favourable for the proper action of the bath upon it. This he found to be that point at which softness or malleability commences, the molecules being then capable of closing suddenly together, thus condensing the material when plunged into a liquid at a somewhat lower temperature than itself, and enclosing some portion of the constituents of the bath in its opened and susceptible pores. Having determined all these conditions, and constructed apparatus, M. de la Bastie was enabled to take ordinary glass articles, and pieces of sheet glass, and to toughen them so that they bore an incredible amount of throwing about and hammering without breaking. Just, however, as De la Bastie had perfected his invention, he lost the clue to success, and for two years he was foiled in every attempt to regain it. There was the hard fact staring him in the face, that he had succeeded in depriving glass of its brittleness, as shown by specimens around him; but there was the harder fact before him, that he had lost the key of his success. Nevertheless he laboured on, and at the end of the period above mentioned he had the satisfaction of finding all his anxieties at an end; his toils were requited by the re-discovery of his secret. He has since worked at it most assiduously, and has now

brought it into practical working order, rendering the process as certain of success as any in use in the arts and manufactures in the present day.

As already observed, M. de la Bastie is not a glass manufacturer; he therefore had to re-heat glass articles when toughening them. It, however, by no means follows that the toughening process cannot be applied in the course of manufacture, thus avoiding re-heating. On the contrary, it not only can be, but has been, applied at glass-works to glass just made, and so saves the costly and time-absorbing process of annealing. But, for reasons stated, M. de la Bastie had to apply the process to the manufactured article, and the method adopted, and the apparatus used in its application, next merit attention. In the first place, the glass to be toughened had to be raised to a very high temperature—the higher the temperature the better—the risk of breaking the glass being thereby reduced, and the shrinkage or condensation being increased. It was therefore advantageous, and often necessary, to heat the glass to the point of softening; but in that condition glass articles readily lost their shape, and had to be plunged into the bath almost without being touched. Then came another difficulty—that of preventing an already highly heated combustible liquid taking fire upon the entrance of the still more highly heated glass. The latter difficulty was met by placing the tempering bath in direct communication with the heating oven, and enclosing it so as to prevent access of air; and the former by allowing the heated glass articles to descend quickly, by gravitation, from the oven to the bath.

The apparatus used by M. de la Bastie is shown in the accompanying Plate CXXII., in which fig. 1 is a front view, fig. 2 a vertical section, and fig. 3 a sectional plan of the oven and bath. The working oven, *a*, is heated by a furnace, *b*. The bottom of the oven, *c*, and the slope to the bath, are made in one piece of refractory material, and are very smooth on the surface. At the side of the oven is a preparatory oven, *d*, communicating by a passage, *e*, in the separating wall. In this oven the glass is partially heated before being placed in the main oven, *a*. The products of combustion are carried away in the direction of the arrows through the chimney. When the oven, *a*, is sufficiently heated, the ash-pit and fire-doors, *f f*, are closed, and rendered air-tight by luting, and the fire is maintained by small pieces of fuel introduced by a hole, *g*, in the fire-door. The draught is then stopped by lowering the chimney cap, *h*, or closing the damper. The vertical damper, *i*, is then raised, so that the flame passes by the flue, *j*, to a second chimney, *k*, fig. 3, passing thus along the slope and heating it, and also opening communication from the oven, *a*, to the bath, *l*, which is filled with the

oleaginous compound. It is covered from the external air by a lid, and within it is a basket of fine wire gauze, *m*, hung from brackets. A tube, *n*, contains a thermometer, *o*, to indicate the temperature; and by this tube the contents of the bath may be added to, or any excess may overflow by the discharge-pipe, *p*. A plug, *q*, on the cover may be removed to observe the interior, without entirely uncovering the bath. A fire-truck, *r*, charged with live fuel, heats the bath to the desired temperature. The glass is introduced into the preparatory oven by an opening, *s*, in the outer wall, and thence it is moved through the opening, *e*, on to the floor of the oven, *a*. The workman who watches the glass through the spy-hole, *t*, when he finds it at the proper heat, pushes it by an iron rod to the slope, *c*, whence it slides into the bath and is received on the basket, *m*. When the glass has cooled to the temperature of the bath, the lid is removed, and the basket, *m*, is raised out of the bath with the tempered glass.

In tempering sheet glass the arrangements of both oven and bath are slightly modified. In place of the sloping exit for articles from the oven to the bath, M. de la Bastie has a rocking table, which is hinged underneath to the mouth of the oven, and which also forms the floor of the oven. When the glass has been sufficiently heated, the workman, by means of a lever, tilts the table, and the glass slides gently down an easy incline on to a table set at a corresponding incline in the bath. If it is not of importance that the transparency of the glass should be preserved, no special precautions are taken to prevent the dust from the furnace settling on its face. Where, however, clearness is required, the glass is heated in a muffle, perfect transparency being obtained. The process of tempering or toughening, exclusive of the time required for heating the glass, occupies but a minute or so, the glass being immersed in the bath and at once withdrawn and set aside to cool. The cost per article, as may be supposed, is merely nominal.

Glass which has been treated in this manner undergoes a physical transformation as complete as it is remarkable. Its appearance is in no way altered, either as regards transparency or colour—if coloured glass be so treated—and its ring or sound is not in any way affected. It has, however, exchanged its distinguishing characteristic of extreme brittleness for a degree of toughness and elasticity which enables it to bear the impact of heavy falling weights and smart blows without the least injury. A great number of experiments have been made, the results of which fully corroborate this fact. From these it will suffice to select a few by way of illustration. Watch-glasses, which perfectly retain their transparency, have resisted every attempt to break them by crushing between the fingers, or by

throwing them about indiscriminately on the bare floor. Glass plates, dishes, coloured lantern-glasses, and the like, have been similarly thrown about by the handful, stood upon, and otherwise maltreated, but without the slightest injury accruing to them, except perhaps when a solitary specimen which had been imperfectly tempered got in with the rest. Experiments have also been carried out to ascertain the comparative strength of toughened and untoughened glass when submitted to bending stress. Here a number of pieces of glass, each measuring 6 inches in length by 5 inches in breadth, and having a thickness of about $\frac{1}{4}$ of an inch, were tried. Each sample in its turn was supported at the ends, and a stirrup-piece was hung upon the centre of the glass, a weight rod hanging vertically from the underside of the stirrup. With this arrangement applied to a piece of ordinary glass, the weight rod was gradually loaded until a weight of 279 lbs. was reached, when the glass broke. A piece of toughened glass of similar dimensions, similarly treated, did not give way until a strain of 1,348 lbs. had been reached, and before it yielded a considerable deflection was produced in it, showing its elasticity. Had its strength been due to rigidity or inflexibility alone, it would not have assumed a curve before yielding to the pressure brought upon it.

Satisfactory as the above results may appear at the first glance, they will be seen upon reflection most inadequately to represent the relative strength of toughened and untoughened glass. It will be observed that the test applied was that of long-sustained and gradually-increasing pressure, which could rarely occur to glass articles in everyday use. Glass is subject to sudden, sharp blows, either from articles falling down on other substances or from extraneous bodies falling upon or being brought into contact with them. Hence it is clear that to obtain a true estimate of the new process glass must be subjected to tests which fairly represent the conditions of the accidents to which it is ordinarily exposed. This estimate has been arrived at repeatedly by placing pieces of plate glass in a frame and allowing weights to fall on them from given heights. One experiment from a number—and which was made publicly—will illustrate this test. A piece of ordinary glass 6 inches long by 5 inches wide and $\frac{1}{4}$ inch thick was placed in a small frame which supported the glass around its edges, and kept its underside about $\frac{1}{2}$ an inch from the floor. A 4-oz. weight was dropped on it from a height of 1 foot, and the glass was broken. A piece of toughened glass of corresponding dimensions was then placed in the frame and the same weight dropped on it several times from a height of 10 feet, but without fracturing the glass. An 8-oz. weight was then substituted, and repeatedly dropped upon the glass from the same height as before, and with the same result, no impression what-

ever being made upon it. The 8-oz. weight was then thrown violently upon it several times, but without damaging it. Its destruction, however, was finally accomplished by means of a hammer. Perhaps the most crucial test to which toughened glass could be put would be to let it fall on iron. This has been done, and in public too. A thin glass plate was dropped from a height of 4 feet on to an iron grating, from which it rebounded about 1 foot, sustaining no injury whatever.

As singular as any other feature presented by toughened glass are the results of its destruction. Ordinary glass, upon being fractured, gives long needle-shaped and angular fragments. Not so toughened glass, which is instantaneously resolved into mere atoms. The whole mass is at once disintegrated into innumerable pieces, ranging in size from a pin's point to an eighth of an inch in diameter. It sometimes occurs that pieces measuring half an inch or an inch across may remain whole, but these pieces are traversed in all directions by a network of fine lines of fracture, and with the fingers are easily reduced to fragments. Microscopical examination shows the fragments of toughened glass—large and small—to follow the same law as regards the form and character of the crystals, and on some of the larger crystals being broken up they have been found to separate into smaller ones of the same character. The edges of these fragments, too, are more or less smooth instead of being jagged and serrated as are those of fragments of ordinary glass. Hence a diminished tendency in the former to cause incised flesh wounds when handled.

When glass has been imperfectly treated, as has sometimes happened in M. de la Bastie's experiments, it will not stand the same amount of rough usage as will perfectly toughened specimens. The fact of the toughening process having been incomplete is made manifest upon the destruction of a sample in three different ways chiefly. Independently of its yielding at an early stage either to blows or pressure, it will show upon destruction either needle fractures approaching in appearance those of ordinary glass, or pieces varying from the size of a sixpence to that of a half-crown will remain unbroken and untraversed by lines of fracture. Again, the mass may be wholly fractured, but on looking at the fragments edgewise a narrow milky streak will be apparent midway between the upper and under sides of the glass, indicating that the influence of the bath has not extended through the glass. Where the process has been perfectly applied, no such phenomena are exhibited, the crystals being of uniform transparency throughout the whole mass.

Such, then, is De la Bastie's toughened glass, which possesses enormous cohesive power, and offers great resistance to the force of impact. There is, however, one peculiarity which, for

the present, tells against it in a slight degree—it cannot be cut through with a diamond. Scratched its surface can be, but there the action of the diamond ceases. This drawback only applies in the case of window glass in odd-sized frames; for the practice of the present day, with builders, is to make window-sashes of certain fixed dimensions, and glass manufacturers work to these dimensions. It is not at all improbable, however, that ere long a means will be devised for cutting toughened glass to any size or shape; experiments are, in fact, now being conducted with this view, and so far as they have gone they give promise of success. But if toughened glass cannot be cut by the diamond, it can be readily cut and polished by the wheel, as for lustres and the like, so that wine-glasses and articles of cut glass-ware can be toughened directly they are made, and cut and polished subsequently.

Superficial observers have affected to detect in the toughening process a similar condition of matter to that which obtains in Prince Rupert's drops. The error of such a conclusion, however, becomes evident upon a little consideration. Prince Rupert's drops are made by allowing melted glass to fall into cold water; the result of which is a small pear-shaped drop, which will stand smart blows upon the thick end without injury; but the moment the thin end, or tail, is broken, the drop flies into fragments. Now, glass and water, and—as far as present knowledge goes—no other substances besides, expand while passing from the fluid into the solid condition. The theory of the Rupert drops is, that the glass being cooled suddenly, by being dropped into cold water, expansion is checked by reason of a hard skin being formed on the outer surface. This exterior coating prevents the interior atoms from expanding and arranging themselves in such a way as to give the glass a fibrous nature, as they would if the glass was allowed to cool very gradually. An examination of the Rupert's drop shows the inner substance to be fissured and divided into a number of small particles. They exist, in fact, in a state of compression, with but little mutual cohesion, and are only held together by the external skin. So long as the skin remains intact the tendency of the inner particles to expand and fill their proper space is checked and resisted by the superior compressive strain of the skin. Nor is the balance of the opposing forces disturbed by blows on the thick end of the drop, which vibrates as a whole, the vibrations not being transmitted from the exterior to the interior. But by breaking off the tail of the drop a vibratory movement is communicated along the crystalline surface, admitting of internal expansion, by which the cohesion of the particles composing the external skin is overcome, and the glass is at once reduced to fragments. As the skin of

toughened glass can be cut through with the diamond, and as, moreover its surface can be removed by polishing and cutting with the wheel, without injury to the mass, it is evident that it must exist under conditions very dissimilar from those of a Rupert's drop. Moreover, melted glass, on being dropped into De la Bastie's bath, gives a similar shaped body, from which the tail can be broken off, piece by piece, without injury to the body, which can be scratched, knocked and thrown about, without exhibiting any signs of deterioration. Bearing upon this point, too, comes the fact that toughened glass can be elegantly engraved, either by Tilghman's sand-blast process, or by means of hydrofluoric acid, in the ordinary way, the surface or outer skin being thus removed.

M. de la Bastie's invention marks a distinct era in the history of one of our most important industries. Never during the history of glass manufacture, which extends over some 3,500 years, has any radical change been effected in its character. The glass-blowers of Egypt, who practised their art before the exodus of the children of Israel, and representations of whom have been found on monuments as ancient as that event, produced a similar glass to that of our own times. This has been proved by an examination of glass ornaments which have been discovered in tombs as ancient as the days of Moses. It has been proved, too, by a large bead of glass, found at Thebes, upon which was inscribed the name of a monarch who lived 1,500 years B.C., and which glass was of the same specific gravity as our own crown glass. It is true Pliny mentions that a combination was devised in the reign of Tiberius, which produced a flexible glass; but both the inventor and apparatus were destroyed, in order, it is said, to prevent the value of copper, silver, and gold from becoming depreciated. There is, however, no evidence whatever that this was the toughening process of De la Bastie, nor does the record in any way detract from the merits of that gentleman as the inventor of an important economic process. The fact remains that the world has now given to it for the first time, in a practical form, an invention by which the brittleness of glass is superseded by an attribute of the most valuable nature—toughness. It is by no means improbable that the old adage, "as brittle as glass," will soon be superseded by a new one—"as tough as glass."

What may be the ultimate result of the introduction of this invention in practice it is difficult to foresee, so widespread, so universal does its application seem. Not only is it desirable to render durable such articles as are at present made from glass, but to satisfy a want long felt in every department of art, science, and manufacture, of such a material as toughened glass; and this want can now be satisfied. So numerous are the oppor-

tunities which present for its application, and so well adapted does it appear to be where cleanliness, transparency, resistance to heat and chemical action, and comparative indestructibility are desiderata, that it would be idle to attempt to categorise them.

The invention is being taken up practically on the Continent, and no less in England. Messrs. Powell, of Whitefriars, are introducing it in their glass works, and two other firms in the north of England are doing the same. It is by no means improbable that its first introduction in practice in this country will be at the aquarium now in course of erection at Westminster, where it is intended to use it for the tanks.

There still remain some questions to be answered with regard to the phenomena exhibited by toughened glass; questions, however, which in no way affect the practical value of the material. Its peculiarities continue to form the subject of investigation, and as soon as any conclusions of value to science have been arrived at, they will be made known, so that the physical aspect of toughened glass may again be reverted to in these pages. In the meantime it may be mentioned, for the benefit of those who are prompted by something more than mere idle curiosity to look a little deeper into the matter, that specimens of toughened glass may be seen at the offices of Messrs. Abel Rey and Brothers, 29 Mincing Lane, City, those gentlemen being the agents of M. de la Bastie. It only remains to observe that the remarkable character and unique nature of M. de la Bastie's invention are such as to render it probable that he will not only materially benefit those of his own time, but will bequeath to posterity an invaluable legacy.

THE ICE AGE.—CLIMATE AND TIME.

By ROBERT HUNT, F.R.S.

IT is exceedingly difficult for the untrained observer to realise the fact, that there was a period, extending over long centuries of time, during which the mountains of the British Isles were covered with perpetual snow, and the valleys deeply filled with fields of ice;—when the temperate sea, which now, with its warm water, laves our shores, was a frozen mass, until far west, and south of Ireland, it broke up into icebergs, which, floating away into the Atlantic Ocean carried the arctic climate yet further southward. Yet the investigations of the geologist have elucidated no more satisfactory truth than this. That there was a period in the history of the Earth's mutations when an ice-sheet was spread over all northern continental Europe, forming an immense glacier in the Baltic, which flowed—as glaciers flow—into the North Sea, and found its outlet to the Atlantic by the English Channel;—when the mountain ranges of Scotland were buried in a frozen mass;—when all northern England and Wales was swept by Scandinavian ice; and, when even the southern and south-western counties were within the influences of a constant temperature below that of frozen water. This was the period which is generally distinguished as the *Glacial Epoch*, but which a recent writer* has, with much terseness, termed the *Great Ice Age*. At what period of time did this arctic climate prevail? Evidence has lately been afforded, especially by the examination of the caves at Settle, that man existed during, or perhaps previous to this glacial age. In the history of man this time, to use Professor Ramsay's words, "though lost in the far backward abysm of time," yet in a geological sense so little preceded our own day, that the larger contours of hill and valley as they yet stand, were already in existence, and probably all the forms of mollusca now living even then inhabited the northern seas.†

* James Geikie. † "The Old Glaciers of Switzerland and North Wales."

It is essential to the understanding of the theory dealing with those vast climatic changes, which the science of geology teaches us to believe it has discovered, by its inductive process of examining the organic remains preserved in, and the physical phenomena engraved on, our rocks, that the evidences collected should be succinctly given.

The evidences of predominance of a high temperature over a defined period, or within a well marked region, will be found preserved in the character of the *flora* and the *fauna*, which existed when the strata, in which their forms are fossilised, was in the progress of consolidation. As tropical life now differs from that which exists within the arctic circle, so through all time similar differences in organisation have been produced by the influences of a high temperature or a low one. We dismiss from consideration in this paper any influence which may be supposed to be due to purely terrestrial heat; the agencies with which we have to deal being sufficiently powerful to overcome, and, as it were, to mask the effects due, if any, to subterranean temperature. The palæontological evidences are numerous and decisive upon the question of the alternations of climate which have taken place in those long lapses of time, during which the surface of our planet has been slowly undergoing those changes, which have produced that succession of stratified rocks, which is the great stone book of Nature, bearing engraved in forcible language, the history of her grand mutations. With those we have only incidentally to deal until we arrive at the Post-tertiary period, when we glean, from the evidences of some great mechanical force which has left its markings, a knowledge of the fact that there ensued a period of great cold, which covered Northern Europe and our own islands with masses of moving ice.

It should be remembered that there can be no doubt but that several long epochs of great cold existed before that period, which is more especially to engage our attention. The fossil remains from which the geologist forms his estimate of the character of a climate during any geological period, are abundant during the epochs which may be distinguished as warm or tropical; but as a general rule those formations which geologists are inclined to believe indicate a cold condition of climate, are nearly devoid of fossil remains. The secular changes of climate which will be more especially noticed as occurring during, and since, the Great Ice Age, were the result of certain physical causes, recurring in obedience to fixed laws, which must have taken place during those vast periods of time which are lost in the infinite past.

Let us now examine—though the examination must necessarily be brief—some of the phenomena presented by existing

glaciers, and then see if similar indications preserved upon the rocks of the Tertiary period, do not lead to the conclusion that they are the result of like causes. The snows which fall upon the mountains of Switzerland are pressed into masses of ice, and these, necessarily in obedience to the force of gravitation, have a tendency to move down their sloping sides.

For a considerable period a discussion was carried on, not always in the true philosophical spirit, as to the physical state of the frozen mass of the moving glacier. One hypothesis regarding ice as a plastic material, moving by virtue of that plasticity, as pitch moves—the other supposing the ice to be melted by the enormous pressure to which it is subjected; but immediately recongealing, or as it is expressed, *regelating* into a homogeneous solid, and thus maintaining its onward motion. We need not here examine the delicate differences between those two views. Since we now know that solid iron, *cold*, may be pressed by a sufficient exercise of mechanical force through small orifices—flowing indeed as a fluid flows—there surely can be no difficulty in conceiving how "the glacier's cold resistless mass" may be forced onward, day by day, by the enormous mechanical power which is ever pressing it in the rear. The writings of Agassiz, and of Professor James Forbes, have rendered familiar the fact that the moving glacier, by its enormous pressure, rounds off the asperities of the rocks, and covers their surfaces with striations. By a steady grinding process all the original angles are worn off, and the whole assumes a mammilated appearance; the surfaces being polished, grooved and striated by the imprisoned stones and finer débris that lie between the solid mass, of the slowly progressing ice, and the rocky floor over which it passes. This moving frozen river of ice carries with it every thing that falls upon it, from the smaller débris, to the huge blocks of rock, which have been broken out of the mountains—*roches moutonnées* and *blocs perchés*—and these are transported by it, to be left eventually, as the ice melts by advancing to a warmer region, to mark the course taken by the glacier. Such are the results of the known movements of glacial ice. When those frozen masses advance into the sea—as they do on the coasts of Greenland—they are gradually broken up into icebergs, which float far away towards the south, eventually melting under the influence of warmer waters, and dropping on the sea bottoms any boulders, or smaller masses of rock, which they may have borne from the land upon which they originated.

These fragments of the disintegrated rocks are left as unmistakable indications of the channels along which the glaciers moved, or of the regions over which the gliding ice of the land, or the floating iceberg of the sea, bore its weighty spoil. This

is proved most conclusively by the effects which are seen to result from the fluctuations in the dimensions of existing glaciers. Professor Ramsay* informs us that, since the year 1767, the glacier of La Brenva rose 300 feet above its present level, and again declined, and the terminal moraines of the Rhone glacier arranged concentrically, one within another, bear witness to its recent gradual diminutions. The great Gorner glacier of Monte Rosa is even now steadily advancing, and is said, within the memory of men not old, to have already swallowed up forty châlets and a considerable tract of meadow land. He continues to remark, that such historical variations in the magnitude of glaciers are trifling, compared with their wonderful extensions in prehistoric times. In the Alps we find numerous instances of the former presence of glaciers where none now exist. "So startling indeed are these revelations, that for a time the observer scarcely dares to admit to himself the justness of his conclusions, when he finds in striations, moraines, *roches moutonnées* and *blocs perchés*, unequivocal marks of the former extension of an existing glacier, more than a long day's march beyond its present termination; and further, that its actual surface of to-day is even 2,000 feet and more beneath its ancient level."

The careful student of these striking indications will, as he ascends the mountain slopes, observe rounded slopes and striated contours to considerable heights above him, plainly marking the breadth and height of the glacier at early periods of its history, and in the uppermost regions the serrated and weather-worn crags that form the lips of the valleys, now almost bare of snow, still define the upward limits where the solid flowing ice in old times ceased to grind the rocks. Beyond this we know that all glaciers deepen their beds by erosion. The enormous weight of the mass of ice moving with irresistible power must tend to grind the surface upon which it moves, and thus cut out channels, and even scoop out lakes from its bed. Indeed, the general origin of lakes has been referred by Professor Ramsay to glacial action, and his hypothesis is supported by evidences which appear to be almost conclusive.

The evidences marked upon the rocks of the globe are the only records which remain of the influences to which they have been subjected in past ages; and, it is only by a proper understanding of the events embodied in these "sermons in stones" that the geologist can hope to give any real value to his deductions. It has been well said by Mr. Croll, in his remarkable book "Climate and Time":—

"No amount of description, arrangement and classification, however perfect or accurate, of the facts which come under the

* "The Old Glaciers of Switzerland and North Wales."

eye of the geologist can ever constitute a science of geology any more than a description and classification of the effects of heat could constitute a science of heat. . . . The principles of heat are the laws of heat, the principles of electricity are the laws of electricity, and these laws are nothing more nor less than the ways according to which these agents produce their effects. The principles of geology are therefore the laws of geology; but the laws of geology must be simply the laws of the geological agents; or, in other words, the methods by which they produce their effects. . . . The facts of geology are as essential to the establishment of the principles as the facts of heat, light, and electricity, are essential to the establishment of the principles of those sciences."

Remembering this, let us advance to a careful examination of the phenomena which have been observed by the trained geologist, and which may be noted by everyone, leading the thinking mind to the conclusion that our globe has undergone changes of climate of the most extraordinary character, convincing us that at one time not only an arctic climate prevailed in our island, but that the greater part of the now temperate regions was buried under ice.

Passing through many of the valleys of North Wales, and especially through that of Llanberis, we cannot but observe that the rocks are round and mammilated, that their smoothed surfaces are often grooved, the striations in this particular instance running north-west, in the direction of the valley, and of the length of the lake. Proceeding up the pass of Llanberis, erratic boulders, mingled with smaller moraine matter, are seen lying on the road side and up among the rocks, which are clearly distinguished from the more modern blocks, and the talus that lie below the weathered cliffs. On both sides of the valley the rocks strewn into blocks frequently present the *moutonnée* (rounded) form. The author already quoted* thus describes one section of this wild and instructive scene:—"Near Pont-y-gromlech bosses of felspathic porphyry rise like little hills in the middle of the valley, something like miniatures of that behind the Grimsel. Though their sides have been scarred by winters' frost and their summits roughened by the weather, they still retain the mammillated form impressed on them of old by the grinding ice; and while the tourist, who sees something in scenery beyond mere external form, is often puzzled to account for the numerous blocks that, perched on precarious points, seem as if they ought to have taken a final bound into the lowest valley, the well-pleased eye of the geologist versed in ice at once detects that they were let gently down where they

* Ramsay, "The Old Glaciers of Switzerland and North Wales."

lie by the melting of the diminishing glacier." Again to quote,—the following description by the same eminent geologist is very conclusive:—

"Above the bridge on the Snowdon side of the valley a great dark wall of rock rises abruptly from the broken lower slopes about a quarter of a mile from the road. From the bottom of the pass it looks almost inaccessible, but half-way up there is a rough terrace, at the foot of a Greenstone dyke that forms, in part, the face of the cliff. The slope of the precipice is about 68° towards the pass, and in one place especially the wall of rock is polished and striated in at least six principal grooves, which slope down the valley (not down the hill) at an angle of 12°. Some of them *are deeply graven from two to two and a half feet wide, and twelve or eighteen inches deep*, and they run so evenly along an almost vertical wall of rock that the idea is at once suggested that they were formed by the long-continued pressure of a glacier so large that it filled the valley to a far greater elevation than the grooves, and by reason of the huge overlying mass of ice, a middle stratum, as it were, of the glacier was jammed against its bounding walls, so powerfully, that by the help of the grinding of imprisoned stones, in time it graved the strong furrows still so perfect. To the very top of the pass, the same kind of evidence, both of moraine débris and striation, continue unabated, especially on the higher slopes on the north-eastern side of the valley, where above the modern shingle and broken cliffs that overlook the brook, numerous *roches moutonnées* remain still hardly unweathered, and here and there are dotted *blocs perchés*." From numerous evidences similar to these, so well described, it appears certain that the ice in this valley must have been in the glacial period at least 500 feet thick, and probably much thicker.

Immediately below the peak of Snowdon scratched fragments are found, and moranic mounds, which in general character are undistinguishable from those which occur in Switzerland. From a most careful study of the whole of this district, Professor Ramsay arrives at the conclusion, that Snowdon formed the centre of six glaciers which flowed from the direction of the peak down the surrounding valleys.

Similar examples to those which have been so succinctly described, are found in abundance amongst the mountains and valleys of Scotland, and spread over England, are indications of the existence of similar influences. On the Cotteswold Hills Dr. Buckland found pebbles of hard red chalk, which must have come from the wolds of Yorkshire and Lincolnshire, and slaty and porphyritic pebbles derived, in all probability, from Charnwood Forest, near Leicester. Nearly all the drift found around Cheltenham has been carried thither from the débris of

the rocks of the Midland Counties. In the vale of Moreton Professor Hull found erratic boulders from two to three feet in diameter, and the granite boulders of Shap Fell are found transported to great distances. The evidences of glaciation in West Somerset exist in the form of "rounded rocky knolls," and beds of gravel and clay, regarded as "boulder-clay,"* similar to that which is found under the recent glaciers of Switzerland. Near the Dodman, in Cornwall, Mr. C. W. Peach found, at an elevation of 60 feet above the sea level, the rock surface well "striated and ice polished." Chalk flints are found in abundance upon Haldon, near Exeter; they are scattered over the wilds of Dartmoor, and not only are they to be found around the Land's End, but they are spread,—sparsely it is true,—over the Isles of Scilly, and they have been discovered imbedded in the mineral lodes of the mines west of Penzance.

The striæ and ice-groovings found on the rocks of these islands—to which we have directed attention—perfectly resemble the flutings and striæ produced in the Alps by the present movements of glaciers, that neither M. Agassiz, or those geologists who have followed him in this path of observation, could detect a difference. The transportation of rock masses to considerable distances could only have been effected by the movements of fields of land-ice, by the floating power of icebergs. The conditions under which the "boulder-clays" are found, and the marked peculiarities of the "glacial drift," sufficiently show that they were produced in this country in Tertiary times, as they are, in our own times, in Switzerland. The conclusion to be drawn from these facts is that an ice-covering must at some period have been spread over the whole, or very nearly the whole, of the British Isles. This ice-covering appears to have extended indeed over the whole of north-western Europe, and to have moved by the way of the North Sea over Scotland, and gradually over Wales and England.

A word on this movement is necessary. An ordinary glacier descends in virtue of the slope of its bed, and it is thin at its commencement and thickens as it descends into the lower valleys, where the slope is less and the resistance to motion greater. The condition of ice formed on level or nearly level land—continential-ice—is different; the slope of the ground exercises little or no influence on the motion of such ice. The ice

* The glacial drift of Caithness is particularly interesting as an example of a *boulder clay*, which, in its mode of accumulation, and *ice-scratched débris*, very much resembles that unstratified stony mud which occurs under glaciers—the *moraine profonde*, as some call it.—Jamieson, "Quart. Journ. Geol. Soc." vol. xxii. p. 261.

can move upon such a surface only in consequence of pressure acting from the interior; that is, the ice sheet must thicken from the edge inwards and then flow upon itself. Mr. Croll estimates that a slope of one degree, continued for 1,400 miles, will give 24 miles as the thickness of ice at the pole. No such thickness as this exists, but it is known to be very considerable. Such land-ice moves slowly, but it exerts enormous pressure. A glacier of 1,000 feet in thickness has a pressure upon its bed equal to about 25 tons on every square foot; consequently, as it extends itself, it carries with it all that it gathers in its course —the results of its own irresistible power. The inference to be drawn from all the facts referred to, is that there certainly was a time when all this country was under a considerable thickness of ice—the result of a very low temperature extending over an exceedingly large section of the globe.

The questions which naturally arise from the contemplation of the phenomena connected with the changes of climate in the earlier history of our globe are—At what period of geological time did the last glacial epoch occur? for how long did it last? and when did it terminate?

We must endeavour briefly to give the answers to those questions which are afforded by the investigations of science.

At one period there prevailed an idea that the subterranean heat of our globe exerted a considerable influence upon the condition of its surface temperature. Sir William Thomson appears to have proved that the general climate of our globe could not have been sensibly affected by internal heat, at any time, more than 10,000 years after the commencement of the solidification of the surface, and he states that the present influence of internal heat on the surface temperature, amounts to about only 1-75th of a degree. Mr. Croll, in his "Climate and Time," says, "Not only is the theory of internal heat now generally abandoned, but it is admitted that we have no good geological evidence that climate was much hotter during Palæozoic ages than now, as some have somewhat hastily asserted, and much less that it has been becoming uniformly colder."

Certain it is that the temperature of the Earth is regulated by radiation of heat from the Sun. Supposing this to be a constant quantity, as we have every reason to do, how is it that we have evidences of great climatic changes? We know that an arctic condition of climate prevailed in our island, and that most of the temperate regions, down to comparatively low latitudes, were buried under ice, and that at another period Greenland and the arctic regions were not only free from ice, but were covered with a rich and luxuriant vegetation.

To explain these great changes, Poisson and others following

him, supposed the Earth to have passed through hotter and colder zones in space. Others have adopted the view that the Sun is a variable star, and that the glacial epoch corresponds to the periods of decrease in the solar heat. Again, it has been a favourite hypothesis with some astronomers that changes in the obliquity of the ecliptic, explains the variations of geological climate, but it can be shown from celestial mechanics, that the variations in the obliquity of the ecliptic must always have been so small, that they could not materially affect the climatic conditions of the globe. The only other view which requires consideration (the former ones being unsupported by any satisfactory evidence) is the change in the eccentricity of the Earth's orbit, the influences of which on temperature have been examined by Herschel and others. Upon the authority of Mr. Croll's philosophical work already quoted, it will appear that if the secular variations of climate which we have been considering be either directly or indirectly the result of changes in the eccentricity of the Earth's orbit, we have the means of determining when these variations took place. If the glacial epoch was influenced by the causes here referred to, Mr. Croll shows that we have the means of ascertaining with tolerable accuracy, not merely the date of its commencement, but the length of its duration. M. Leverrier determined the superior limit of the eccentricity of the Earth's orbit, and he has given formulæ by means of which the extent of the eccentricity for any period, past or future, may be computed. From tables constructed by that eminent astronomer, it has been computed by Mr. Croll—supposing it to be admitted that the glacial epoch was in any way dependent upon the alterations of eccentricity —"that it extended over a period of 160,000 years. But as the glaciation was only on one hemisphere at a time, 80,000 years or so, would represent the united length of the cold periods."

By a careful examination of the amount of denudation effected during the glacial epoch, it has been supposed that the surface of the country was ground down by the ice, to the extent of one-tenth of an inch annually, which gives upwards of 650 feet of matter removed from the surface during the whole of the glacial epoch. By determining the rate of subaerial denudation, which is ascertainable by learning the quantity of matter which is carried off the land at the present time—that is, by ascertaining the amount of sediment annually carried into the sea by the river systems—we have an approximate measure of time since the close of the glacial epoch. The facts of geology appear to prove that the close of the Great Ice Age does not date back beyond 80,000 years.

It has been thought by some geologists that alterations in the distribution of land and water would produce the changes

of climate to which we have been referring, and without doubt they would do so; but it is now generally agreed that little or no such change has taken place, and that all our large continents and islands not only existed in the glacial epoch, as they do now, but that the very contour of the Earth's surface was pretty much the same then as it is now. If an island, a "New Atlantis," ever existed between the British Isles and America—cutting off the influence of the Gulf Stream—there is no doubt the conditions of our climate would be greatly altered. But there is no evidence of any such island ever having existed. We are therefore driven back to an examination of the influence of the increase of eccentricity; and although it could not directly lower the temperature of our country and cover it with ice, yet it might bring into operation physical agents which would produce this result. The argument of "Climate and Time" is, that a high state of eccentricity would produce deflections of the ocean currents, and materially modify their effects, thus producing variations of climate upon the continents and islands within the influence of their waters. To such an extent is the temperature of the equatorial regions lowered, and that of temperate and polar regions raised, by means of ocean currents, that were they to cease, and, each latitude to depend solely on the heat received directly from the sun, only a very small portion of the globe would be habitable by the present order of beings.

Although it has been contended by Arago, Humboldt and others, that climatic variation is but very slightly influenced by changes in the elliptical form of the Earth's orbit, yet there is every reason for believing that the oceanic currents do suffer deflection by such changes. Consequently, if the Gulf Stream were stopped in its circulation northward, and if the heat conveyed by its waters was deflected into the Southern Ocean, this would enormously lower the temperature of the northern hemisphere, and elevate it in a corresponding degree to the south of the equator.

With the physical causes of oceanic circulation, it is not at present possible to deal. There are two theories which attempt to account for it—one referring the circulation to the influence of wind, and the other to the effect of *gravitation*. The relation which these hypotheses bear on the question of the changes of climate, may be made clear in a few words. When the eccentricity of the Earth's orbit attains a high value, the hemisphere, whose winter solstice occurs in aphelion, has its temperature lowered, while that of the opposite hemisphere is raised. If we suppose the northern hemisphere to be the cold one and the southern the warm one, the difference of temperature between the equator and the north pole will then be greater than between the equator and the south pole. If the circulation of oceanic

streams is dependent upon difference of temperature, the equatorial waters would be deflected more into the northern than into the southern hemisphere, and thus the eccentricity, by influencing *indirectly* the physical causes at work, may be regarded as materially influencing the conditions which produce the last, and probably all other yet more ancient glacial epochs.

The temperature of our country is known to depend upon the influence of those oceanic waters which are warmed in the Gulf of Mexico. When—as they have done as we suppose for 80,000 years—these waters come to our shores charged with a certain residue of that tropical heat which they have gathered by convection from equatorial lands, they yield it up for our benefit, producing that equalisation of temperature in which the British Islands rejoice.

If, in the progress of change—which is the law of nature—there eventually should occur an alteration in the eccentricity of the Earth's orbit, and consequent upon it, a deflection of the Gulf Stream southward, the hills and valleys of now fertile England would again be brought under the influence of extreme continuous cold, and there would be a renewal of another Great Ice Age.

Plate. CXXIII.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RECENT RESEARCHES IN MINUTE LIFE.

By HENRY J. SLACK, F.G.S., Sec. R.M.S.

[PLATES CXXIII. and CXXIV.]

OBSERVERS have not yet arrived at sufficient knowledge of a great number of the minute organisms known as infusoria to classify them in a satisfactory way. This is especially true of the Monadina, or monads, under which name many heterogeneous creatures were placed by Ehrenberg and Dujardin. Recently Haeckel has proposed to group together, under the name Monera, those lowest organisms which, at their highest state of development, are composed of sarcode in a simple structureless state. These Monera he places in the lowest rank of Protista, a kingdom intermediate between animals and plants, which "reproduce themselves by monogony and not in a sexual manner."* Amongst the Protista are the so-called Moners, Flagellates like Euglena, &c., Labyrinthula, Diatoms, Fungi, Amœbæ, Rhizopods, &c. It certainly cannot be affirmed of all these organisms that they reproduce by monogony to the exclusion of a true sexual process, and as the life-history of only a few have been fairly made out, many supposed different species may prove to be only various forms of the same creature. It is, moreover, somewhat begging the question to say of any small living object that it possesses no organisation because we cannot perceive it. The minuter forms are in many cases so small that it is difficult to see them as wholes with the highest objectives, and many probably escape vision altogether. When the whole is scarcely visible with the best appliances, it is mere dogmatism to say that it has no differentiated parts. The lowest kind of organization may differ little from the molecular arrangements which give the crystals of many substances different optical properties in different directions, and may continue to elude any means of investigation we possess. How low down in the scale of being true sexual processes occur is still a matter of speculation.

* "Mic. Dic." 3rd edition.

Analogy would make it universal. Messrs. Dallinger and Drysdale have traced it amongst a group of minute monads, and it has been found in many of the fungi. With regard to the latter, the reader may be referred to "Cooke and Berkeley's Fungi, their Nature, &c." and to M. Von Tieghem's experiments on the fecundation of *Coprinus ephemeroides*, a little agaric found on dung. He confirmed the statements of M. Reess respecting *C. stecorarius*, and showed that this fungus produced male elements in the form of minute rods, and these behaved somewhat like pollen to the female cells.* The recognition of sexuality in fungi is not new, and it is many years since M. Tulasne discovered that some of them produce spermatozoids. M. Claude Bernard observes that "sexuality is the paramount, universal, and necessary mode in which resides the true unity exhibited in the entire series of animals and plants. Its mechanism may be complicated and very uncommon, but physiological analysis succeeds in demonstrating their essential identity when reduced to their elementary conditions."

The germs of some organisms are so minute as to defy detection with existing means. We shall find this the case with some of the monads investigated by Messrs. Dallinger and Drysdale, and the fact is alluded to by Dr. Burdon Sanderson in his paper on "The Pathology of the Infective Processes."† He is speaking of the bacteria connected with splenic disease, first discovered by Pollender, and at a later time independently by Davaine, and remarks: "Although the blood of animals affected with splenic fever always contain the staff-shaped bodies if it is examined at a sufficiently advanced period, the disease can be communicated by the inoculation of blood in which these bodies either are not present, or at all events not in such numbers as to admit of their being made out microscopically. This was originally stated by Brauell, and has been recently confirmed by Bollinger. . . . . . It has been proved experimentally that two liquids of the same chemical constitution, and placed under exactly the same circumstances (*i.e.* both completely protected from external contamination), may stand in an entirely different relation to the ordinary bacteria which pervade all aqueous media, the difference consisting in this: that whereas one of the liquids is proved to be prone to the breeding of bacteria by their appearing in it, as if spontaneously, the other may be kept for any length of time without such development taking place."

In another passage the same authority observes: "In common ubiquitous bacteria, those which are concerned in putrefactive changes are known to be, in their ordinary active state,

* "Comptes Rendus," Feb. 8, 1875.

† "Public Health Reports," New Series, No. 111. 1874.

easily destroyed. Thus they are unable to survive complete desiccation or a temperature higher than 80° C. On the other hand, it is equally well ascertained that masses containing bacteria are not deprived of the power of originating new generations of these organisms by heat, unless they are either subjected to a temperature considerably higher than that of ebullition, or boiled for a very long period. The reason of the apparent discrepancy is to be found in the fact that the bacteria have two modes of existence, the one characterised by permanence and resistance, the other by rapid development and short duration; that in all bacterial masses which have the power of resisting high temperature; *e.g.* in cheese, there exist, in addition to the ordinary forms of readily killed bacteria, other living particles of more stable structure. The properties of such bodies, to which Professor Cohn assigns the name of lasting spores (*Dauersporen*), are only just now beginning to occupy the attention of mycologists."

Dr. Sanderson is mistaken in supposing that "resting spores," as they are commonly called, are only just beginning to occupy attention. It is ten years since Mr. Berkeley published a paper in the *Intellectual Observer** "On the Resting Spores of certain Fungi," in which many illustrations were given. It is quite probable that bacteria may produce resting spores, and very likely at certain stages of their existence a sexual process occurs, and the germs resulting from it have great powers of resisting heat.

A confirmation of the views of Dr. Burdon Sanderson has just been obtained through the experiments of M. Feltz "On the Poisonous Principle of Putrefied Blood."† He found that even the powder of blood that had been putrefied to that stage in which bacteria, &c., perish, and then dried, could set up septicemic disease when mixed with water and injected into dogs' veins. He concluded that germs of bacteria, which he could not detect with the microscope, had survived the putrefaction and desiccation, and were able to produce a new race of the infusoria.

Where the germinating power of an ovule depends upon nitrogenous matter like common albumen, which coagulates and becomes insoluble at 60° C. (140° Fahr.), it is easy to understand why a temperature short of boiling kills it; other nitrogenous bodies do not seem to lose their properties until actually burnt; and it would not be surprising if organic germs should exist which can only be destroyed by a temperature at which wood becomes scorched.

* Vol. vi. p. 31.

† "Comptes Rendus," May 31, 1875.

The fungologist recognises the same species of many fungi under various forms so discrepant that only a study of their life-history could lead to the belief that they were in any way related. Messrs. Dallinger and Drysdale show this to be the case with certain monads; and probably a great many infusoria are able, at certain stages of their existence, to give rise to other forms, if the surrounding conditions are favourable. The yeast plant and allied fungi, according to M. Pasteur, are able to change their mode of living if introduced into new circumstances, sufficiently young. In one state they are consumers of the oxygen of the air, but they can live in fluids containing none of that substance, and then their vital processes are carried on through the power they possess of decomposing bodies which contain it. He divides certain organisms into two classes: *aerobies*, which require air, and *anaerobies*, which can do without it, although capable of using it. The latter act as ferments when deprived of air, and join the *aerobies*, ceasing to be ferments when it is supplied to them. These opinions were contradicted by experiments of MM. Brefeld and Traube, but confirmed by fresh researches of M. Pasteur, who discovered that his opponents had, in one case, not employed young yeast cells, but only older cells, whose habits, so to speak, had become fixed; and, in another, admitted extraneous bodies, which affected the result.* These observations may suggest important inquiries with reference to organisms supposed to cause disease. Besides the fungi mentioned by M. Pasteur, many other organisms may act as ferments, or not, according to their surroundings, and this may make all the difference between their innocence and their noxiousness.

The researches of Messrs. Dallinger and Drysdale may well be considered in connection with facts like the preceding. They operated chiefly with an infusion of cod's head, which produces after the ordinary forms that occur in putrefying matters, several remarkable monads. In some cases the creatures they describe did not appear until the infusion had been kept for many months.

Their first observations related to the monad in Pl. CXXIII., fig. 1, which multiplied by transverse fission. First came an hour-glass constriction, and both ends of the little animal tugged away from each other until the sarcode at the thinner portion was stretched out to a fine thread, and finally snapped to make new flagella when the separation was completed. After this mode of division had gone on for a period extending from two to eight days, some of these monads became amœboid, as shown in fig. 2, where they are beginning to coalesce. The coalescence

* "Comptes Rendus," Feb. 22, 1875.

continued until a round mass was formed, and this, bursting, poured out streams of infinitesimal spores. These were so minute that "with the 1–25th (Powell & Leland's) the most accurate observer could not have discovered their presence if he had not previously seen them with 1–50th." Gradually growing and developing, these germs reproduced the parent forms.

Their next set of observations led to still more curious results. They were made on the form represented in fig. 3, which rarely appear in the cod's-head infusion under three or four months. Its average length is about 1–3000th of an inch. The lower flagellum of this monad enables it to anchor itself, and having done so, it springs backwards and forwards, somewhat like *vorticella*, "except that the uncoiling was as rapid as the coiling." When this creature multiplies by transverse fission, the anchoring flagellum becomes involved in the process and divides, and the same takes place when the fission is vertical, as in fig. 5.

Now comes the remarkable part of these studies, which shows the triangular object (fig. 7) to be one of the life forms of fig. 3, and that the globular one (fig. 6) is only another stage. The masses like fig. 6 push out the little projectile *c*, terminating in a flagellum. The mass elongates, the new flagellum divides, a constriction forms slanting across the animal, and shortly it divides into two monads, which move off and establish connections with the ordinary forms, and from the fusion of the two arise the triangular forms like fig. 7. These, losing their flagella, and somewhat changing their shape, pour out from their three corners floods of extremely minute particles, which prove to be growing germs.

Thus we find an ovoid biflagellate monad, a globular creature, and a triangular one, the last of which, from its aspect, might be supposed another species, to be only different states of the same thing. The globular creature splits into ovoid monads: they enter into conjunction with other ovoid monads and form the triangular creatures which pour forth myriads of spores that reproduce the ovoid shape; but how do the globular ones arise? Occasionally some larger anchoring sorts appear, become amœboid, and finally globular.

The cod's head infusion in an advanced state of decay yielded another monad with an equally remarkable history. It is represented in fig. 8, the size being from 1–3000th to 1–4000th of an inch in its long diameter. One of its flagella is permanently hooked at the end, and acts as the locomotive organ, carrying the creature onwards in a series of jerks. This monad multiplies by fission, but occasionally two enter into conjunction, one being distinguished by a knot at the end of his non-hooked flagellum (see fig. 8), where they are almost in contact. The

lesser and under monad becomes absorbed in the upper one; the two form "a yellowish gelatinous flabby mass," which grows spherical. Then two little openings appear at opposite points of the margin, with a faint line connecting them; these two now giving the appearance of fig. 9. Fresh openings and radii then appear between each of the first four, and after a time the creature exhibits spots and lines all over its surface, somewhat like *volvox globator*. Further segmentations ensue, and finally a host of little monads are discharged. Sometimes four or six monads enter into conjunction instead of only two.

Still another monad from the fish infusion afforded a new series of facts. It is seen in fig. 10, and is about 1–4000th of an inch long, but usually rather less. Its peculiarity is multiple fission. First it rounds itself, then becomes a little indented, then like a cross-bun, then as in fig. 11, then like a bundle of little curved maggots, and lastly comes their separation as monads of the parent form.

These, too, like the preceding, had their sexual mode of reproduction. Some appeared larger and plumper; they fastened on the common ones, as in the last case; the absorption of the smaller one took place, a round mass formed, and bursting, scattered a cloud of spores so small that they could only be seen in a mass "like strong spirit poured into water." No granules could be discovered even with the 1–50th objective, but seven hours after their emission tiny dots appeared with a magnification of 5,000 diameters. They came suddenly into view, as if by quick growth, and developed rapidly.

After a cod's head maceration had been kept for twelve weeks, a peculiar monad appeared, represented in fig. 12. In another case a year passed without its appearance in a similar infusion of salmon's head, and what determines its coming is unknown. It exhibits a distinct hyaline envelope, and its hinder part contains granular matter, above which is a nucleus-like body. In fig. 6 a division is seen in progress inside the envelope, which keeps its shape. When the division is complete each of the new ones thus formed divides again, and sometimes as many as sixteen are formed in this way, the whole swimming about like volvox, until one or more begins to rupture the envelope, and they all escape except perhaps one or two, which die.

Some of the normal forms of these monads grow more granular than others at their posterior end. They are usually larger than their brethren, swim freely, and suddenly dart out their granules. When first expelled these granules are amorphous, but after a time little spots appear in them, which become very lively in about forty minutes, and finally escape as minute bacteria-like bodies. In four or five hours more they assume the

parent form. The observers were rewarded for their most patient watching by seeing at last the sexual reproduction of these creatures. Two coalesced in a rounded mass and burst, pouring out a swarm of minute spores, as described in other cases.

Strange as it may seem, the fish maceration afforded another remarkable and elegant monad, which its discoverers term, from its shape, the calycine monad. This is shown in fig. 14, and exhibits a considerable complication of structure. Like other monads this multiplies by fission, becoming first partly amœboid, but it also proceeds by sexual union. Fig. 15 shows two of them, which have assumed a conical amœboid condition, uniting themselves together. When this process is complete they make a sort of plum-shaped sarcode mass, in a sac with a few corners, but nothing like the curious amœboid form. This sac becomes round and smooth, then bursts, discharging swarms of extremely minute germs. When these germs begin to develop, they look about from a fiftieth to a twentieth of an inch long when magnified 5,000 times linear measure, and they gradually take the parent form.

In the preceding account of Messrs. Dallinger and Drysdale's researches a great many matters of interest have been omitted, and for such details the reader is referred to the series of their papers in the "Monthly Microscopical Journal," 1873–5. One very curious and common feature was the possession by the monads of an "eye spot," which opened and shut in a snapping manner. Exactly what this organ was could not be discovered; but its presence, together with that of a nucleus, suggests a more highly organised condition than was previously known in such minute organisms. The facts here cited show that monads of excessively small size, after multiplication for an indefinite number of generations by fission, resort to a sexual process, that their germs resulting therefrom are so minute as to be invisible except in a mass with the highest and best objectives at present made, and that the life series of the same creature comprehends forms so different that they would be referred to different species, or in some cases to different genera,. or even families, if the order of their succession had not been made out.

The germs or spores of these creatures resisted very high temperatures; those of the cerco-monads 260° F. (178° C.). The "springing monad," as its discoverers call the one that anchored and behaved somewhat like vorticella, and made a multiple fission, did not emit the cloud of minute sporules, and was destroyed by less heat. No adult form withstood a high temperature, but as great a heat as 300° F. did not destroy the minute sporules of the uniflagellate form. The biflagellate germs survived 250° F.

After these remarks it is impossible to admit that simple

boiling destroys all germs, or that because no germs can be discovered with the highest powers none exist. There are no data by which any limit can be assigned to the minuteness of creatures that may possess a complex organisation, unless indeed mathematicians concerning themselves with molecular physics compute it at something far beyond our possibilities of vision. Probably the minutest of known forms does at some period of its life-history resort to sexual generation, as Claude Bernard supposes.

The question will arise, how do such facts, and suppositions drawn as inferences from them, accord with theories of *abiogenesis*, which is a less perplexing term than spontaneous generation. Abiogenesis supposes that, under certain conditions, matter not derived by descent from previously living matter, can set up vital processes and grow. The opponents of this theory accept in a broad sense the old Harveian doctrine *omne vivum ex ovo*, and believe that no inorganic matter becomes organic except under the directing force of a germ that had a living parent. Under any hypothesis we must admit the probable existence of germs we cannot see, perhaps some so small that our eyes can never behold them, as they may be beyond the limits any optical aid we may obtain can reach. We have also no reason for supposing that a heat of 300° necessarily destroys all germs, and if all are killed at a higher one the abiogenist would still need, for the complete working of his theory, to suppose that no possible heat could prevent inorganic matter, under certain conditions, from becoming organic. Doctrines of evolution, beginning with a nebulous condition of our own and of other globes, require us to imagine that life existed potentially, if not actually, through the fiery stages of condensation when the earth was a surging molten mass, or that it was introduced from without when the cooling had proceeded far enough. Most believers in development doctrines would probably prefer the first of these suppositions, and expect that, by further advances of science, connecting links and steps of transition will be found between inorganic and organic matter—between non-living and living substance. There is an evident convergence of all sciences from physics to chemistry and physiology towards *some* doctrine of evolution and development, of which the facts of Darwinism will form a part; but what ultimate aspect this doctrine will take there is little if any evidence to show, and perhaps it will not be shaped by the human mind until metaphysical as well as physical inquiries are much more advanced. If, on the one hand, there are thinkers who try to materialise all that others call spiritual, there are philosophers who, so to speak, spiritualise matter, and expect matter and spirit to prove opposite sides of the same thing.

Darwin's remarkable speculative guess of pangenesis is still

the most probable way of accounting for the phenomena of heredity, and we need not be scared from it on account of the extreme minuteness that must be assigned to the representative particles of which germs must be composed. M. Béchamp has recently stated that the microferments he discovers in eggs are so small that eight thousand millions would be required to fill the space of a cubic 1–25th of an inch. The sporules not visible as single bodies in the Dallinger and Drysdale observations under a magnification of 5,000 diameters must be still more minute, and yet they must be composed of parts, and contain that variety of matter which appears essential to germinating action. When a microscope just enables us to see very small bodies as distinctly separable from each other or from the fluid in which they may be found, their real size cannot be nearly as great as their apparent size. Most objectives would far more than double their diameters by optical errors, and if the best added only a hundred-thousandth of an inch, that would be a very important enlargement; so that in speaking of the actual dimensions of the smallest germs known we must use figures that transcend our conceptions of dimensions as much as those employed by astronomers do when they talk of billions, trillions, and other unimaginable mile-distances in the realms of space.

DESCRIPTION OF PLATES CXXIII. AND CXXIV.

The figures in these plates are copied from the illustrations to the researches of Mr. Dallinger and Dr. Drysdale. "Monthly Microscopical Journal," 1873-4.

FIG. 1. Biflagellate Monad.
FIG. 2. Two that have become amœboid in process of conjunction.
FIG. 3. Monad that anchors with one flagellum.
FIG. 4. The same in process of fission.
FIG. 5. The same in vertical fission.
FIG. 6. A globular form which elongated and divided into two Monads. Monads thus formed enter into conjunction with the preceding, and coalesce in the shape of fig. 7.
FIG. 7. Triangular form resulting from coalescence, as above.
FIG. 8. Hooked Monads about to coalesce.
FIG. 9. Spherical form, resulting from the coalescence, segmenting.
FIG. 10. Uniflagellate Monad.
FIG. 11. The above, after having rounded itself in an advanced stage towards multiple fission.
FIG. 12. A multiple fission Monad.
FIG. 13. The same in fission.
FIG. 14. Calycine Monad.
FIG. 15. Two of the above in conjunction after becoming partly amœboid.

THE TENDENCIES OF SYSTEMATIC BOTANY.

By M. C. COOKE, M.A.

IN the commercial world it is considered a laudable proceeding on the part of any honest trader to pause once or twice in the year and review his position, take account of his stock, consider the transactions of the immediate past, and determine on future operations. The reckless adventurer may not deem any such process essential, but thereby he neither merits the confidence or esteem of those who are worthy to bestow it. So also is it incumbent on those who pursue science to pause, if not so frequently, at least occasionally, and reflect on the past, contemplate the present, and forecast the future, in so far as his own particular study is concerned. Whether he shall always keep silence as to his conclusions, or communicate them as a warning or encouragement to others, may be matter of opinion. There may be times when to be silent is little short of treachery, especially when there is ever so small a hope that by indicating rocks ahead the vessel may be directed into a safer channel.

The number of those who take an interest in the tendencies of any one branch of biological science is comparatively small, and probably those who interest themselves in botanical subjects are by no means so numerous as those interested in entomological or other sections of zoology. Still the few are entitled to regard, and to them the estimate which one of their number may feel it imperative to make of the tendencies exhibited by the systematists of the day may not be without interest or importance.

It may be premised that although the writer will draw his conclusions, and educe illustrations from his own special branch of the science, he does so in full confidence that the tendencies which he purposes to indicate are not peculiar to that branch, but are more or less present in all. The experiences of others having been canvassed and compared with his own, he believes that there are good grounds for the conclusion that not only amongst the lower, but also amongst the higher orders of plants, the same practices prevail, and the same tendencies are making

themselves felt. What is true of fungi is true also of Lichens and unicellular Algæ; it may be also of the higher Cryptogams; certainly the fears expressed by those most capable to judge of the aspects of Phanerogamic Botany point unmistakably to the same conclusions.

Every allowance must be made for the extended and universal use of the microscope, which has so much increased our knowledge of the minute structure of plants during the past quarter of a century. It may be that this continual resort to the microscope has given to minute structural differences an undue characteristic importance in some instances; but more than all, it has induced a method of closer observation; it has fostered the faculty of seeing, whilst at the same time it has dimmed the power of recognising broad and general affinities. Every minute hair and scale is depicted with fidelity, and every cell numbered, whilst the general contour is forgotten, and the broad effects of light and shade which pleased our forefathers is lost in the pre-Raffaelite adoration of the trivial and ornate.

Some ten or twelve years ago the makers of species ostentatiously ranged themselves on two opposing sides, so that "splitting" and "lumping" for a time became the watchwords of parties; but the controversy on what constitutes a species has subsided into comparative indifference, and theory has given way to practice, leaving on record hundreds of doubtful species for future generations of botanists to puzzle over and ultimately discard. So long as the fashion was in the ascendant for dividing one species into twenty, no very permanent injury was threatened to the future of botanical science. Labour was largely increased it is true, but the old generic distinctions remained, and the mischief was at least limited by recognised boundaries. Ultimately, however, a new direction for activity was discovered, and genera no longer received their old respect. The pent-up waters burst their bounds, and threatened a new deluge far more disastrous than its predecessor. This leads to a consideration of the primary tendency of the age, which commenced by elevating individuals to the rank of species, and now threatens the fate of Babel by the confusion of all generic distinctions.

Anyone who has observed closely the progress of systematic botany during the past few years cannot fail to have noticed the great and sudden increase in the number of genera, out of all proportion to new botanical areas. By a closer inspection it will become evident how this great accession has been accomplished. The old genus of Discomycetous Fungi accepted by Fries under the name of *Peziza* in his "Systema," published in 1822, was still recognised with very slight modifications by the same author in 1846, and at that time no one thought of proposing any alteration; indeed, some of the groups which he

then separated under new generic names did not meet with any general acceptation. When Professor De Notaris subsequently propounded a scheme for the rectification of the classification of the Discomycetes, it scarcely met with consideration. The spirit of the age had not yet set in in the direction of change. It would be scarcely necessary to allude to subsequent works, or just to charge upon any one or two individuals the questionable honour of splitting up the genus; especially when this one has been selected, not as an isolated instance, but as a type of many others. Without attempting to enumerate the genera which have been proposed to occupy the place formerly held by *Peziza*, one work may be taken as a type of others: it is the Flora of a Duchy of Germany, and in this the species of *Peziza* are distributed over no less than thirty-six genera, for thirty-five of which the interests of science made no demand whatever. It may unhesitatingly be pronounced that the whole of these thirty-five genera are based upon insufficient characters, and that their only merit is to exercise the memory and introduce unnecessary confusion. Another objection might be urged against them, that they are not constructed on any one principle. Here two or three genera are based on the presence or absence of a stem, there on the globose sporidia. In one instance the characteristic feature of the genus is the presence of a sclerotioid base to the stem, in another the thick sulcate stem, and in another the urceolate form of the cup. If such features are to be considered as sufficient, then nearly every species might be regarded as the type of a new genus. Surely if it is sound to construct a genus for stipitate species with globose sporidia, it must be equally sound to construct another for sessile species with globose sporidia, another for stipitate species with elliptical sporidia, another for sessile species with elliptical sporidia, and thus through the whole range of the forms of sporidia. Such a method, however unnecessary it might be, and liable to other objections, would still be consistent. In the case of other genera, such as *Sphæria*, the main features of the new genera are the form, colour, and septation of the sporidia, so that at least the method has more of uniformity.

It would be almost universally admitted that the genus *Peziza*, as limited by Fries, was one of the most natural in the whole range of fungi. It may be cited as evidence of this that students and persons little acquainted with fungi seldom erred in referring each species to the proper genus. The main features of a fleshy cup with a smooth disc commended itself at once; and although there might be a thousand species, the whole arrangement was characterised by simplicity, and fulfilled all the requirements of classification; surely nothing more was requisite. It is quite immaterial whether a genus contains one species or

one thousand; it should no more be contended that because a genus is a large one it must be cut up into a number of smaller ones, for the sake of convenience, than to determine that no genus shall consist of more or less than twenty species. Numbers are wholly beside the question, and *convenience* is not science. In this instance we think that the inference is sound that one of the tendencies of the systematic botany of the day is the unnecessary multiplication of genera.

It may be urged that the evidence adduced of the reduction of one large genus does not warrant this conclusion. Perhaps it would not, if this were an isolated instance, but it is only one of too many. Without passing from the asci-bearing fungi we have in the genus *Dothidea* another analogous instance. The same flora, as cited above, contains eight genera in place of the one constituted by Fries. This is hardly the place to discuss the merits of the different genera proposed in the place of one which also was a very natural one and required no modification. To constitute a genus like *Homostegia* on the basis of the habitat of the species is so unsound that it only needs applying the same principle throughout the genus to convince any unprejudiced reader of its absurdity. If one habitat is to be accepted as the characteristic of one genus, why not another? Manifestly these are only, at the most, sectional or specific differences; or if generic in one case, why not in another? If generic, then species of *Dothidea* found on grasses, on leaves, on ferns, on twigs, on herbaceous plants, &c., have each as good a claim to be regarded as distinct genera as *Homostegia*.

Should this be considered insufficient, attention might be directed to the genus *Sphæria*, according to Fries, and the modifications proposed by more recent authors. Again, taking the same flora as our guide—which by-the-bye is by no means an extreme one, and does not include many proposed new genera—we find that forty-eight genera represent the old genus *Sphæria*, or rather as limited by Fries in 1846. Here again the limits of the primary genus were clearly defined, and the new genera have not been constructed for the reception of anomalous forms, but entirely by the breaking up of the parent genus. Botanists will comprehend at once the toleration with which we would accept the constitution of a new genus in which to place one or two anomalous species, which differed in some permanent, though it might be rather unimportant feature, from the genus to which it had been affiliated. But there is not even this excuse for the majority of genera into which the species of *Sphæria* have been unceremoniously transferred. A little excuse may be made for the removal of species with a membranaceous perithecium from companionship with those in which the perithecium is more or less carbonaceous; but

on the whole the multiplication of genera was uncalled-for and unnecessary, and the new genera are constructed on unsound principles.

All the genera in this group (*Ascomycetes*), before the irruption of the Goths and Vandals, were constructed on the principle that generic characters should be based fundamentally on the vegetative system, leaving the reproductive for specific distinction; that is, differences in the size, form, colour, and septation of sporidia, had a primary importance in the discrimination of species, but had no generic value. The character of the receptacle which contained this fructification had the chief place in the generic diagnosis. It was possible under such a method at once to refer an immature or an effete specimen to its genus, though not to its proper species. The new genera are mainly constructed on the basis of the reproductive system, and consequently the mature fruit must be known before the proper genus can be determined. It is well known that in species of *Sphæria* which have ultimately sporidia with five septa, these sporidia are at first simple; they then in process of development become uniseptate, afterwards triseptate, and finally five-septate. There are thus three of the supposed new genera through which the same species passes before it arrives at its final determination. A specimen found to-day with simple spores may be determined as belonging to one genus; a week hence it may be found again with uniseptate sporidia, and is then referred to a second genus; a week or two later, and it is met with having triseptate sporidia, and is referred to a third genus; and finally it may be found with five septa to the sporidia, and receives still another generic name. This is manifestly playing at science. There is often no internal evidence whatever at the different stages that septation will proceed further; and it is only by finding sporidia and asci in different stages of development, in the same peridium with the triseptate or quinque-septate sporidia, that the life-history of the plant is learnt with certainty. There is another reason why this basis of classification is unsound, and that is the very different character of the vegetative system, the external habit and appearance of different species of *Sphæria* with very similar fruit, not to mention a certain amount of variability in the sporidia themselves. Even in the case of coloured sporidia, which is often made a chief generic feature, it is well known that some species are very long in acquiring their brown colour, and may be found ten times with colourless sporidia to once with coloured sporidia. Into what difficulty must the student be plunged when, instead of finding his *Sphæria* with hyaline sporidia, in a genus so characterised, to be informed that he must seek it in one devoted to species with coloured sporidia!

It cannot be an answer to this argument that the sporidia are imperfect when they do not bear the evidence of imperfection, and it is only from experience that the ultimate character of the sporidia can be known. In the face of this fact it is manifestly unsound to base classification on features which require first of all that it should be determined what is the life-history of the plant, and whether it has arrived at the final stage of its development, before its genus can be fixed. From this as well as previous illustrations it may be urged that, not only is there a tendency in the systematic botany of the day unnecessarily to multiply genera, but also to construct them upon unsound principles.

References might be made to other orders—as, for instance, of such genera as *Uromyces*, *Capitularia*, and *Puccinella*—all which are so identical that no sane mycologist would think of separating them from *Uromyces*, unless it might be by way of excuse for attaching his own name after them, and calling them new species. The most recent systematic arrangement of the *Myxogastres* also demonstrates with what extraordinary facility a batch of new genera can be extemporised from old materials.

It would be difficult to estimate with any certainty the number of recognized genera in fungi. The second edition of Lindley's "Vegetable Kingdom" enumerated 544; these were increased to 813 in the third edition (1853), and in the intermediate twenty-two years the increase may be fairly estimated as bringing the total number to not less than 1,000, exclusive of a great many that are acknowledged to be spurious or synonymous. The same or even greater difficulty exists in the determination of the number of species. Fries, in his "Epicrisis" (second edition), gives characters of 2,778 species of *Hymenomycetes* found in Europe. Hence it may fairly be concluded that the total number of species of *Hymenomycetes* is not less than 5,000, leaving a less number for the rest of the world, inclusive of North America, which is very rich, and the large number of *Polyporei*, &c., found in tropical countries. The number of good species of the *Discomycetes* which we have recently had occasion to study closely and critically is not less than 2,200, and the residue of the *Ascomycetes* will not be less than double that number. Consequently we think that it is a very safe estimate to place the number of species of fungi at 20,000. With such a number of plants it may readily be imagined with what concern those who are intimately attached to their study regard innovations which are calculated, not only to increase their labour to an alarming extent, but threatens to bring the whole of that branch of the science into inextricable confusion. The same fear is beginning to take possession of Lichenologists, and those who have devoted themselves specially

to the *Diatomaceæ* have been heard to intimate their dissatisfaction at the tendencies of the age. If we had not found an echo to our fears in those who have to deal with flowering plants, we had not ventured to attribute the tendency exhibited in relation to fungi to the whole area of systematic botany.

Some mycologists have still sufficient faith in the soundness of the principles on which the Friesian genera (for so they may be called) were constructed, that they are content to adhere to them in practice, and will only accept a very few of the new genera. On the other hand, if some recent floras are to be taken as evidence, certain mycologists seem resolved to adopt as many as possible of the new genera, excluding the old ones; so that two concurrent systems may be said to be coming into vogue—a double series of names, an unending catalogue of synonyms—leaving to a future generation the Herculean labour of discovering the good grain amongst so great an abundance of chaff. It is almost impossible for any person to keep pace with the rapid evolution of genera and species, to read and endeavour to comprehend them, much less store them in their memory, to note the conflicting interpretations of the same genus, to see two or three species accepted by one, rejected by another, or divided by a third; so that one feels constrained to add still another conclusion—that the tendency of the systematic botany of the day is rapidly towards chaos and inextricable confusion.

The free *emendation* of the characters of long established genera is another fertile source of mischief. The practice is by far too common so to alter and *emend* (?) an old genus as to limit considerably the number of species it can include; and this consequently lends excuse for the subsequent proposal of new genera to contain the species excluded from the old one by this process of manipulation. This leads to confusion as to the interpretation which is to be attached to the generic name, whether it is to be accepted as proposed by its author, or the more limited sense attached thereto by the emendator.

In a like manner the method of dealing with the parasitic Coniomycetous fungi may be alluded to. This method is probably confined absolutely to fungi, and has nothing analogous in other branches of botanic science. It has long been suspected—we cannot say demonstrated—that some of the species of *Puccinia* have relations of a peculiar nature with certain species of *Æcidium*, which are, according to this theory, but another form of development. However strong the conviction may be in some minds that this is really the case, it is surely premature to act as though the relations were satisfactorily proven, and *emend* the nomenclature accordingly. This course, though unsound and reprehensible, has been adopted, and advantage has been taken, by these radical reformers, of a change in the diagnosis

of the genus *Puccinia*, by unison of *Æcidium* as an hymeniferous stage, to replace the names of the venerable authors of the original species by their own; and Persoon, De Candolie and others, have been thrust aside to make room for the Schmidts and Schneiders of the new age. It has even been deemed a sufficient warrant for superseding the name of the original author attached to a species of *Puccinia*, to cite, or suppose some special form of *Trichobasis* as its uredo-form. By this means one large or variable species has afforded material for a dozen or twenty. It is most probable that each species of *Puccinia* has its uredo-form, although it is very doubtful whether they have been accurately assigned in all instances when the attempt has been made, often upon the slightest semblance of evidence. It is doubtful whether, in cases where mycologists have given new names to supposed species of *Puccinia* on the assumption that they have found the hymeniferous state in some *Æcidium*, or the uredo-form in some *Trichobasis*—wholly ignoring specific names previously applied to the bicellular, or most perfect condition, by old authors—should not find their new names discarded, and the old names revived, even if their suppositions prove true. To some persons the method resorted to by certain species-makers of discarding recognised names seems like "sharp practice;" it may be that harsher terms are applied to those who have effaced older and worthier names on an excuse so paltry, and which must fail to secure them the esteem of thoughtful workers in a future generation, when the fashion of the day has passed away.

It is scarcely necessary to refer at length to the acknowledged tendency towards increasing inordinately the number of supposed species. To secure uniformity of recognition of the limits of species is a hopeless task; nevertheless, sometimes the most credulous are subject to severe trials of faith. It is a relief to contemplate the terse and compact manner in which all the characteristic features of a species are compressed within the limits of two or three lines by some of the older botanists, as compared with the prolix thirty or forty lines in which attempts are made to characterise some new species, which the author himself scarcely seems to believe in. Constant care is necessary, not only against following example but too widely extended, but to guard against mistaking the variability of individuals for specific differences. The broader and more extended experience becomes, the larger the number of the same undoubted species and its allies which the botanist is privileged to examine from remote habitats or distant parts of the world, the less disposed is he to construct species hastily; and hence we find that the most irrepressible makers of new species are usually those whose experiences are confined within narrow limits. Exceptional cases may be found in those who are called upon to describe the flora of a new country.

There is perhaps another tendency, which exhibits itself stronger in the present day than at any previous period, which may be alluded to in passing; and that is the practice of applying complimentary specific names. It is always preferable that a specific name should, if possible, indicate the principal feature, or one of the principal features, which distinguish the new species from its congeners. In a large genus this is not always possible; but it is to be feared that such a desirability never presents itself very strongly to the mind of those who are continually complimenting their friends, or flattering their patrons, by attaching their names to some obscure plant. It is amusing to note in most cases how speedily Professor Jones returns the compliment which Doctor Smith has paid him, and how promptly the *Sphæria Smithii* of Jones follows the *Sphæria Jonesii* of Smith. Less exception can be taken to the dedication of a new species to the memory of a deceased botanist who may have made that genus a special study; but mutual interchange of such compliments between living men, who should have greater respect for their science than to make it subservient to flattery, is no great compliment to their own judgment. Instances could be cited in which officers of state, nobles, and honourables, have been called upon to accept the dedication of a new species to their name. What a satire these men must think such exhibitions to be on the science which thus professes to honour them. It is somewhat anomalous that some of the most objectionable forms of this tendency are exhibited by citizens of the first Republic of the world. Their wives and female acquaintances, upon a little quiet reflection, could hardly thank them for sending their names down to posterity spiritually wedded to some blight, mildew, or other destructive fungus. Taste probably differs on either side the Atlantic.

We have freely commented on such of the tendencies of the age in regard to systematic botany as have most forcibly impressed themselves on our minds; and whilst we have done so, it has not been hinted that we regard British botanists as sinners before all others. On this point we desire that no misapprehensions should exist. The "silver streak," or some good fortune, has as yet spared us from the epidemic which seems to prevail so extensively on the Continent. As far as our own experience goes, it is with no little pleasure that we exonerate the systematic botanists of these islands from participation in the follies, and worse than follies, to which we have thought it expedient to direct attention. It is earnestly to be hoped that in these matters they will not import their fashions from abroad.

It is scarcely expected of us to speculate on the sources of

these tendencies, but they do in some sort seem to be related to the temper of the times in other matters. There is a lacking of respect, almost a defiance of authority, an impatience of restraint, a desire for change, a restlessness and dissatisfaction at old barriers and landmarks, an assertion of individual right to think and act independently of every one and every thing else—all the tendencies which manifest themselves in times of political activity—and which expend themselves in various directions when the political activity subsides. It can hardly be expected that science alone should escape the influence of events that stir nations to their last man; and though the relation of cause to effect may be difficult to trace, there may at least be good ground for speculation.

For the future, we would still hope that some seasonable check will intervene to prevent the consummation of the designs of those who would completely overthrow all the labours of those who have toiled in this branch of science. We have faith in the few who have not bent the knee to Baal making their protests heard, and that time and reflection will also aid in convincing those who are now foremost in destruction that their work is not progressive but retrogressive, and that it is better to build than to destroy.

THE PAST AND COMING TRANSITS AND ARCTIC EXPLORATION.

BY RICHARD A. PROCTOR.

THE materials obtained during the recent transit of Venus have been gathered together, and though many months must elapse before the definite solar distance to which they point can be ascertained, we already possess the means of forming an opinion as to their general value. The result is not altogether that which had been anticipated by any among those who were interested in the preliminary arrangements and preparations; though, on the whole, it would appear that the astronomers of America formed the justest anticipations respecting the probable course of events. I am not, of course, referring here to accidental circumstances, such as the weather at this or that station. It must be clear that the best laid plans were liable to be defeated by conditions of weather; for though some of the stations were placed in regions where the weather probabilities were exceedingly favourable, and others unfortunately (but necessarily) in regions exposed to almost continual storms, yet nothing could be *confidently* predicated, even respecting these stations, and far the greater number had simply the ordinary chances of fair or foul weather. It happens, indeed, that of the two most favoured regions, Egypt and New Zealand, the former barely sustained its reputation (the sun at some stations only just clearing a cloud bank in time to be seen), while the latter had worse fortune than any other region of like extent. On the other hand, several stations where bad weather was regarded as too probable—as St. Paul's Island, Auckland Island, and Kerguelen Land—had very favourable weather. I may notice, in passing, that even as respects the manner in which weather probabilities were dealt with, there was a wide difference between the American and our English manner of acting. For we find

that the official astronomers responsible for the English plans considered the unfavourable weather likely to prevail over most of the more suitable southern regions was a sufficient reason for having *fewer* southern than northern stations. The American astronomers held just the contrary opinion. "From all the reports," says Professor Newcomb, the chief of the Washington Observatory, "it was found that the chances of good weather were much better in the northern than in the southern hemisphere; therefore, instead of sending an equal number of parties north and south, it was determined to send three to the northern and five to the southern hemisphere."

But it was in the actual observation of the phenomena of the transit that circumstances were noted which most significantly affect the value of the various methods. These circumstances I proceed now to consider, as on them must not only depend the opinion we are to form respecting the arrangements which should be made for the transit of 1882, but also the value we are to attach to the results secured last December.

In the first place, it will be remembered that though doubts were expressed in many quarters as to the possibility of determining the moment of internal contact with great accuracy, the doubts so expressed were based chiefly on a phenomenon called usually the "black drop." It had been supposed that the greater part of the error in the determination of solar parallax from the transit of 1769, had arisen from the difficulty caused by the "black drop." Some observers were assumed to have taken for the moment of true internal contact the instant when the edge of Venus seemed to separate from the sun's at ingress, or to join the sun's at egress—a sort of dark ligament suddenly breaking in the first case, and as suddenly forming in the second case. Other observers were assumed to have judged when the outline of the undisturbed part of the planet's disc belonged to a circle which, if complete, would have just touched the sun's edge. The interval between the first kind of contact and the second, or between real contact and apparent contact, was assumed to have a constant value—seventeen seconds. This done, and the observations passed through what Leverrier has called the "grist-mill" of the method of least squares, there came out a result agreeing very well with the values of the sun's parallax obtained by other methods. Unfortunately it so happened that many of the observers in 1769 noted contacts of both kinds, and instead of finding the difference to be seventeen seconds, or thereabouts, they observed differences varying from twenty to forty seconds, and in one or two instances attaining a yet greater value. This of itself would have sufficed to deprive the explanation of all real value; but it was further

noted, by Continental and American astronomers, that the whole process by which explanation was attempted corresponded to what school-boys call "fudging," or working backwards from the answer to the data of the question, with "allowance for error," whenever any discrepancy seemed disposed to make an appearance.* Nevertheless it was not doubted that the "black drop" is a real cause of difficulty and error in observing contacts, and very elaborate preparations were made to overcome this difficulty. Models of the transit were constructed, both in Europe and in America, on different plans—one devised by a Continental astronomer, the other by the American astronomers at Washington. Elaborate theories were devised to account for the peculiarities and varieties of the observed phenomena. And it was judged, not without reason, that the "black drop" would not cause the same degree of trouble, during the transit of 1874, as it had occasioned in 1761 and 1769, or at least to the mathematicians who had to deal with the results then obtained.

But when the transit was actually observed it was found that the "black drop" was a much less serious cause of trouble than another which, though recorded by observers in 1769, had somehow received much less notice than it deserved. Professor Grant, in his fine work, "The History of Physical Astronomy," thus describes what was known of the phenomenon in question before the recent transit:—"It was remarked, by several observers of the transits of 1761 and 1769, that both at the ingress and egress the portion of the limb of the planet that was off the sun was visible by means of a faint light surrounding it in the form of a ring. La Chappe, who observed the transit of 1761, at Tobolsk, in Siberia, states that the light of the ring was of a very deep yellow near the body of the planet, but that it became more brilliant towards the outer border. MM. Stromer, Mallet, Bergman, and Melander, who observed the same transit at Upsal, remarked that when three-fourths of the planet's limb had entered upon the sun, the remaining fourth was visible by means of a faint ring which appeared around it. A similar phenomenon was observed on the same occasion by Wargentin at Stockholm, by Planmann at Cajenburg, and in several other instances. Dr. Maskelyne, who observed the ingress of Venus upon the sun's disc at Greenwich, on the occasion of the transit of 1769, states that, when the planet was little more than half entered upon the sun,

* For instance, the difference of seventeen seconds just mentioned was inferred from the result required, not from the facts given.

he saw her whole circumference completed, by means of a vivid but narrow and ill-defined border of light, which illuminated that part of her circumference that was off the sun. He adds that it disappeared two or three minutes before the internal contact. A similar phenomenon was witnessed during the same transit by Wales and Dymond at Hudson's Bay, by Pingré and De Fleurien at Cape Francis, in the Island of St. Domingo, and by various other observers at different places."

A little consideration will suggest the true cause of this appearance, and will show that its effect on the observation of internal contact cannot but seriously affect the accuracy of the timing. No light can show itself round the portion of Venus outside the sun, between the moments of exterior and interior contact, unless the planet has an atmosphere capable of refracting the solar rays; but if the planet has such an atmosphere, the observed effect cannot but be produced. If we suppose an observer on Venus at a point, P, on the part of her limb most remote from sun—P not being the point which is seen from the earth at that part of the limb, but so placed that the true horizon-plane for an inhabitant of Venus there is parallel to the line from the observer on earth to the centre of Venus—then, if there were no atmosphere, an observer at P could see neither the sun nor the earth, at least not where the terrestrial observer is placed. The sun would be just below the true horizon of the observer on Venus, and so would the observer on earth; and *à fortiori* the observer on earth would not be able to see the sun round the part P of Venus. This part would be, as it were, the summit of a hill, from which the sun on one side and the earth on the other would be invisible, and therefore invisible from each other. But if there is an atmosphere on Venus resembling our own atmosphere in its effects, the observer at P would see the sun raised by refraction above his horizon, and the earth directly opposite raised considerably above the horizon—precisely as at the time of total lunar eclipse the observer on earth, if so placed that the eclipsed moon is apparently just above the horizon (really raised by refraction), can see the sun also directly opposite the moon, and raised wholly above the horizon. And as the line of sight from the observer at P to the sun on one side, and to the earth on the other, is thus twice bent by refraction, so the line of sight from the observer on earth to P is curved doubly as it passes P, and the sun is brought into that observer's range of view. The same is true for all points round the part of Venus's limb outside the sun, the atmosphere of Venus bringing greater and greater quantities of sunlight round the dark limb the nearer the part of the limb is to the sun. Thus there is seen round the arc of

Venus, outside the sun, a ring which is not to be regarded as mere sunlight, but as a distorted image of the sun himself.*

The effect of this phenomenon in modifying the conditions under which internal contact is observed will be recognised at once. Observers were told to look for the moment when a line of sunlight suddenly made its way between the disc of Venus and the solar limb at ingress, or when the gradually narrowing line of sunlight was suddenly broken at egress. But here was true sunlight bounding the disc of Venus long before true contact took place at ingress, and long afterwards at egress, so that the time to be noted was not that suddenly marked by the formation or breaking of a line of sunlight, but that when the sunlight, bounding the part of Venus outside the solar disc, was seen at ingress to become merged in the true outline of the sun, or at egress just began to disturb that outline. The observation to be made was of precisely the same order as an observation of external contact, and it had long been admitted that external contact cannot be timed with sufficient accuracy to supply evidence available for determining the solar parallax.

The very first news which reached us on the morning of December 9 pointed to this difficulty, or rather to this circumstance practically rendering contact observations untrustworthy. We heard from the head of the English party in Egypt that, after internal contact had in reality been established at egress, an arc of sunlight still remained visible around the part of Venus which was outside the sun; and that the observer, through waiting for this arc to break, lost the best cusp-measurements. Captain Tupman gives the following account of the phenomenon as observed at the stations where the transit began earliest of all, viz. the set of stations on the Sandwich Isles:—"The important phase of the phenomenon of internal contact presented wholly unexpected appearances, totally unlike what we had been led to anticipate. For many minutes before contact a faint light was seen behind Venus, beyond the sun's limb, rendering the complete circle of her disc visible. From that time until the establishment of complete contact no sudden or definite phase could be seized upon, such as the practice with the working model induced us

* This not only happens when Venus is placed as described, but when her whole disc is off the sun's. Professor Norton has seen the whole circuit of Venus surrounded by a border of light at the time of inferior conjunction (within transit). In such a case the semicircular arc of light nearest the sun consists, in the main, of reflected sunlight, and the remaining arc, in the main, of refracted sunlight.

to watch for. The eye-observations of contact, therefore, do not present results of extreme value." Lieutenant Noble, at the same station, describes the phenomenon as follows:—"From about 10 min. of the time of internal contact I kept the telescope pointed on the sun's limb. While thus watching I was astonished to see, most distinctly, the disc of the planet complete, and immediately asked Lieutenant Shakespear what time remained before contact. He said a little over 5 min." Mr. Nichol, at Honolulu, writes:—"To my astonishment I saw a completion of light round the planet perfectly distinct, and such as I should have said, from previous model contact, was immediately after contact. I got this time recorded as the first observation of contact by seeing the continuous narrow band of light. I remained looking at it about two minutes, but could see no instantaneous phenomenon of contact, nor black drop." He supposed the peculiarity due to light from the solar corona; but, under the conditions of observation, that explanation is quite untenable. We cannot wonder to find Captain Tupman mentioning that Mr. Nichol recorded a time forty-seven seconds earlier than he did himself. Captain Tupman says further that "there was nothing sudden to note" (as had been expected), "and the complete submergence was so gradual, anyone might have recorded ten seconds before I did, and have been probably quite as accurate. My first impression was [that] such an observation could not possess any value. It was something similar in principle to having to decide where the zodiacal light terminates! bearing in mind, of course, that we expected to get the contact within a second or so of time."

We can understand, then, the justice of the remark in the recently issued "Report to the Board of Visitors of the Greenwich Observatory," that while "there has been little annoyance from the dreaded 'black drop'" (Mr. Stone's bugbear), "greater inconvenience and doubt have been caused by the unexpected luminous ring round Venus;" though why the phenomenon should have been unexpected, when Maskelyne, himself an astronomer-royal, recorded it so distinctly in 1769, is left unexplained. A very small amount of labour given to the examination of the records of former transits would have prevented this well-known phenomenon from taking the observers by surprise; or, perhaps better, would have suggested that contact observations were little likely to be of use.

It may be well to supplement the above account by quoting the description of the same phenomenon as seen at St. Paul's Island, one of the "inaccessible if not absolutely mythical islands" of our Admiralty authorities, which the French (not usually regarded as more essentially nautical than we are)

succeeded in occupying.* Immediately after the first indentation of the sun's limb had been observed, M. Mouchez began to measure the distance between the cusps. "About a quarter of an hour," he proceeds, "after the first contact, when half the planet was still outside the sun, I perceived suddenly the entire disc of Venus, defined by a pale halo, brighter near the sun than at the summit of the planet" (that is, at the part remotest from the sun's edge). "To make sure that I was not under an illusion as regards this unexpected phenomenon I immediately reversed the position-circle of the micrometer to 180°, and measured that diameter of Venus which was still partly outside the sun, and I found it identical with the diameter perpendicular to the lines joining the centres; it was, therefore, really the entire well-defined disc of the planet which I saw. But, in proportion as the second contact approached, the two extreme portions of the halo nearest the sun (and more distinctly seen) tended to unite, surrounding the segment still exterior to the sun with a brighter light, and this *too early* union (*réunion anticipée*) of the cusps by a luminous arc was rendered still more perfect by a narrow border of very bright light bounding the aureole on the disc of Venus. Foreseeing at once that there would be great difficulty in observing the geometrical contact, even if it would not be absolutely impossible, I quickly changed the darkening glass of pale blue for one of deeper tint, by means of which I hoped to extinguish this halo with its accidental gleams (*lueurs accidentelles*), but it was useless: the halo still remaining visible, I was obliged to take the original darkening glass again. Under such circumstances, I had to take as the moment of contact, not the meeting of the two cusps, or the geometrical contact, but the moment when the sun's disc no longer seemed disturbed by the bright light which enveloped the planet at the point of contact. I observed a very sensible time-difference between the moment when I *believed* the contact might have been established and the moment when I *felt absolutely certain* that contact was established. . . . . The third contact was also observed under excellent conditions, in very clear sky between clouds, with the same phenomena as at the second contact, but in reverse order."

It needs no elaborate argument to show that this peculiarity must altogether prevent the observation of contacts with the degree of accuracy necessary to *improve* our estimate of the sun's distance. With the improvement of telescopes the phe-

* At another of these myths (Campbell Island) the French observers had bad weather, unfortunately, during the transit. But the Germans, at a third myth (Auckland Island), saw the whole transit.

nomenon will only be so much the more clearly recognised; and it must be quite impossible to experiment on this phenomenon as on the "black drop," seeing that we cannot represent by a model the action of an atmosphere whose real extent and refractive power are unknown to us.

Nor can photography be of any use in this matter; for the more perfect the photographic arrangements, the more exactly will the optical difficulty be reproduced. Indeed, in the photographic records of contact, during the recent transit, a peculiarity appears, which seems, of itself, to introduce an absolutely insuperable difficulty. It would seem that the sun, which photographs itself, is slightly *larger* than the sun we see; in other words, that the gaseous matter of the sun emits light-waves, producing that form of chemical action on which photography depends, from layers extending to a greater height than those which emit light-waves recognisable by the eye in full sunlight. Janssen, at least, adopts this interpretation of the fact, that at ingress, as observed at Nagasaki, the planet appeared still attached to the solar limb, while the photographs taken, second by second, showed Venus already somewhat advanced on the sun's disc. It matters, in truth, very little whether this explanation is correct or not, seeing that the observed fact, however explained, indicates a discrepancy between the optical and the photographic records of contact which must prevent our placing reliance on either.

If we abandon contact observations, but one resource seems to be left. It is manifest that all methods have for their real object the determination of the chord of transit followed by Venus, as seen from different stations. When reliance was placed on Halley's method, for instance, although the element observed was the duration of transit, the element deduced was the length—and with the length the position—of the chord of transit. When reliance was placed on Delisle's method, the element observed was the epoch either of ingress or egress; but the element deduced was the *position* of the ingress or egress end of the chord of transit, and therefore of that chord itself. The great difficulty in all other methods of determining the position of the chord of transit resides in the fact that the exact position of Venus on the sun's disc (not merely her distance from the centre, but her bearing from the centre, referred to some fixed line on the sun's disc,) must be determined for a precisely-timed moment. So that a double difficulty is introduced; first, the observations necessary to determine Venus's position require time; secondly, the exact longitude of the station should be known with as great accuracy as for Delisle's method. But the central part of the chord of transit—the part, namely, where the

planet makes its nearest approach to the sun's centre—has this advantage over the other parts: the planet's distance changes so slowly as it is passing this portion, that an error of a few seconds would be comparatively of small importance. Moreover, this part of the chord is the most important because the distance of the chord from the sun's centre is what is really required. Now, setting aside the heliometric method, by which it was hoped that the distance of Venus from the sun's centre might be accurately determined, photography promised a means of indicating the required element very satisfactorily, because a solar photograph is secured in the fraction of a second, and ample means exist for indicating the precise instant at which each photograph is taken.

In a paper, the geometrical principles indicated in which were professedly adopted by Government astronomers in the choice of stations for photographing the late transit, I showed how the difficulty of indicating the exact angle of position of the line joining the centres of the disc might be obviated, and everything made to depend on the measurement of the distance between the centres, assuming the longitude of the station known, and the exact instant of each photographic record assigned. It did not seem to me necessary to point out that, as the time of mid-transit drew near, the effect of any time-error (whether in the indication of the instant of exposure, or in the determination of the longitude of the station) would be diminished; for this is a fact, not only obvious in itself, but taken for granted in the discussion of the whole matter by all who have considered the geometrical relations involved. So that I took it as self-evident that mid-transit was the time when photographic records for determining the chord of transit would have greatest value. And it was easy to perceive that, in some cases, it might be advantageous to select stations, either solely or chiefly with reference to the important phase of mid-transit; in other words, to select stations where neither the beginning nor the end of transit could be photographed under favourable conditions, but where the middle of transit would be most advantageously observable. However, when this obvious particular case of the general theory I had dealt with was pointed out by Mr. E. L. Garbett, I presented the suggestion as though it contained somewhat of novelty, not caring at that time to show how completely it was included in the general reasoning advanced by Colonel Tennant, Dr. De la Rue, and, more fully, by myself.* On the occasion of the late transit only

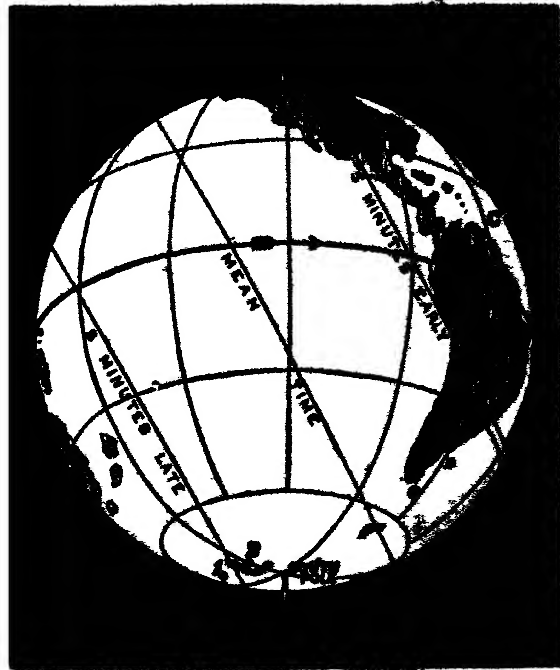
* Nor should I now call attention to the point but that the special form of thanks adopted by Mr. Garbett for what, in reality, was unnecessary

FIG. 1.

SUN-VIEW OF THE EARTH AT THE BEGINNING OF THE TRANSIT OF 1882.

FIG. 2.

To face page 273.



SUN-VIEW OF THE EARTH AT THE END OF THE TRANSIT OF 1882.

one station was specially suited for mid-transit photography—Cape Town. Though Natal would have been worth occupying, Cape Town was superior to every other southern station for this particular purpose. But somehow the suggestion that photographs should be secured there was overlooked, and a new cause of regret added to several which will be recognised by those who come after us as they scan the history of the late transit.

But in 1882 this method—the mid-transit photographic method—will be the one on which, I venture to predict, chief reliance will be placed. Owing to the long duration of that transit (exceeding, by two hours, the duration of the recent transit), it will be impossible to find any pairs of stations, northern and southern, at each of which the whole transit will be favourably seen. This will be manifest from figs. 1 and 2, showing the face of the earth, turned sunwards, at the beginning and end of the transit of 1882. It will be seen that, though the dotted stations in the north will be well placed throughout the transit, there are no southern stations well placed for both the beginning and end. For to be well placed they ought to be at once near A of fig. 1, and near D of fig. 2; and these two points (owing to the long duration of the transit) are far apart on the earth's surface. The points marked 1 and 2 are those best placed in a geometrical sense; and these were indicated, eleven years ago, by the Astronomer Royal, as points one or other of which ought to be occupied by Great Britain in 1882. But apart altogether from the difficulty of occupying these stations on the antarctic continent, they are neither of them well suited for observing both the beginning and end of transit; the sun being very low at both stations at the beginning of transit, and at one of them at the end of transit also. So far, then, as the older methods of observing transits are concerned, the transit of 1882 can only be observed by Delisle's method. But we have seen that contact observations cannot be relied upon for improving our knowledge of the sun's distance. And if they could not be relied upon for that purpose now, still less can they be relied upon in 1882, before which time astronomers will have secured valuable determinations of the sun's distance from observations of the planet Mars, during the singularly favourable opposition of 1877.*

But mid-transit can be advantageously recorded by photo-

generosity, consisted in denunciations addressed to me for overlooking the point which had appeared to myself and others too obvious for special mention.

* It may well be hoped that stellar photography will be employed to obtain records of the position of Mars among the stars on that occasion. This method seems to promise better results than any other yet applied, or at present available.

graphic appliances in 1882, if only suitable southern stations can be occupied for the purpose; and, as no other method is available, except the demonstrably untrustworthy Delislean method, we can scarcely doubt that an effort will be made by the scientific nations to overcome the difficulties which will certainly present themselves in the search for and occupation of stations in the southern hemisphere. The nature of these difficulties will be at once recognised from fig. 3, which shows where are the best stations of all. It will be seen that in the

Fig. 3.

Sunview of the Earth at the middle of the Transit of 1882.

northern hemisphere there will be an enormous extent of land-surface where the parallactic displacement will be great (exceeding half the maximum at stations on the northern side of the northern line, marked 5), and the solar elevation sufficient (exceeding 20° at stations within the circle marked 20°). But the corresponding southern region is, in the geographical sense, most unfavourably placed. It is indeed precisely in the heart of this region that the title is placed, in Mercator's

charts, because of the absence of any known islands in that part of the South Pacific Ocean.

And there will be this further difficulty in 1882. On the occasion of the late transit the Americans, finding that no part of the transit would be visible from their own territory, appear to have considered it their natural and obvious duty to occupy stations in Siberia, Japan, the sub-antarctic ocean, and other places, where we in England were assured that no stations *would* be, and that no stations *could* be occupied. But in 1882 the whole transit being most favourably observable from the whole of the United States, it seems not unlikely that our Transatlantic cousins will consider it their part to keep their astronomers at home, leaving to other nations the task of finding suitable southern stations. I hesitate to say that this *will* be their view of the matter, for it is difficult to reckon on considerations of that kind where Americans are concerned. One might have thought, that after observing the eclipse of 1869 at a hundred stations in the United States, American astronomers would have been content to leave the observations of the Mediterranean eclipse of 1870 to European astronomers. But, in point of fact, they did nothing of the kind; but, with a perversity which cannot be too strongly reprehended (at least by all who admire our *laisser aller* system), they insisted not only on sending over astronomers, but on positively inviting English astronomers (finding we had made no arrangements for observing the eclipse) to sail with their expedition to inaccessible Mediterranean regions. However, supposing that in 1882 the attractions of the transit, as observable at home, should prevent Americans from visiting the southern hemisphere in great strength, the duty will fall on European nations. Germany and France may then, as last December, occupy three or four southern myths. But three or four will not be enough. England will be almost bound to share in the work.

Then arises the question, Where is England to send her observers in those southern seas? Unless new islands can be discovered there, no positions worthy of her ancient fame will remain for her to occupy, save precisely those antarctic islands which were described, in 1868, by one naval authority after another, as accessible, tenable, and suitable, but, unfortunately, by the same authorities, in 1873, as inaccessible, untenable, and unsuitable. Assuming, as we may not unreasonably do, that the later description meant only that it would cost more time, trouble, and money to occupy these regions than any conceivable astronomical result could repay, we are brought back to the considerations which were urged by the Astronomer Royal as long ago as 1865, in order to bring schemes of ant-

arctic explorations favourably before the notice of geographers and naval authorities. With these considerations I shall conclude; merely remarking, that whatever force his views had when presented, they have greatly increased force now that an arctic expedition is in progress, the value of the results obtained by which would be far more than doubled by a successful antarctic expedition following close upon the successful issue of that which has lately set forth. "I have learned," he wrote to the President of the Geographical Society, "through the public papers, the tenor of late discussions at the Royal Geographical Society in reference to a proposal for an expedition towards the North Pole. I gather from these that the object proposed, as bearing on science, is not so much specific as general; that there is no single point of very great importance to be obtained, but a number of co-ordinate objects whose aggregate would be valuable. And I conclude that the field is still open for another proposal, which would give opportunity for the determination of various results, corresponding in kind and importance to those of the proposed Northern Expedition, though in a different locality, and would also give information on a point of great importance to astronomy, which must be sought within a few years, and which it is desirable to obtain as early as possible. In the year 1882, on December 6, a transit of Venus over the sun's disc will occur—the most favourable of all phenomena for solution of the noble problem of determining the sun's distance from the earth, provided that proper stations for the observation can be found. (It will be remembered that it was for the same purpose that the most celebrated of all the British scientific expeditions, namely, that of Captain Cook to Otaheite in 1769, was undertaken.) For the northern stations there will be no difficulty; they will be on the Atlantic seaboard of North America, or at Bermuda; all very favourable and very accessible. For the southern stations the selection is not so easy; the observation must be made on the Antarctic Continent; if proper localities can be found there; and if the circumstances of weather, &c., are favourable, the determination will be excellent; if those favourable circumstances do not hold, no use whatever can be made of the transit. The astronomical object of a southern expedition is, I trust, sufficiently explained. In the event of such an expedition being undertaken, the precise determinations which I have indicated as bearing on the astronomical question must (from the nature of the case) take precedence of all others. But there would be no difficulty in combining with them any other inquiries, of geography, geology, hydrography, magnetism, meteorology, natural history, or any other subject for which the localities are suitable. And I have now to request that you will have the kindness to communicate

these remarks to the Royal Geographical Society, and to take the sense of the Society on the question, whether it is not desirable, if other scientific bodies should co-operate, that a representation be made by the Royal Geographical Society to Her Majesty's Government on the advantage of making such a reconnaissance of the Southern Continent as I have proposed; primarily in the interest of astronomy (referring to my official responsibility for the importance of the examination at this special time): but conjointly with that, in the interests, perhaps ultimately more important, of geography and other sciences usually promoted by the Royal Geographical Society."

WAS MAN A CONTEMPORARY OF THE MAMMOTH?

By JAMES D. DANA.

THE evidence of the contemporaneity of Man and various extinct Quaternary Mammals in Europe and Great Britain is complete: that is, it is beyond reasonable doubt or question; for (1) it has been gathered with great care by the best of geological observers; (2) it has been verified through the re-examinations of reported cases by other able geologists; and (3) it has been further verified by the special investigations of committees of scientific societies.

The North American facts thus far announced have not, unfortunately, the same broad basis for confidence.

Among the earlier of the reported discoveries are the two in Missouri, brought out by Dr. Koch. The account of them has often been cited by writers on the subject; and Mr. J. W. Foster, in his "Pre-Historic Races of the United States of America," prefixes to the citation the remark that Dr. Koch, at an interview with him, during the last year of his life, assured him, "in the most solemn and emphatic manner, that his statement was true." Mr. Foster also observes that "to deny the accuracy of his statement is to accuse him of having attempted to perpetrate a scientific fraud"—a decision not sustained by the ordinary rules or treatment of evidence; for science has constantly to guard itself against the assertions of men who are honest, but are not experienced in scientific investigation, and in all such cases rightly asks for corroborating testimony. Moreover Dr. Koch's statement of his facts may be true, and still his conclusion as to their proving the contemporaneity of Man and the Mastodon in North America be wrong.

The question which American Science should carefully consider—as carefully and guardedly as has been done for similar cases in Europe—is, whether Dr. Koch was a competent observer, and whether his observations are a sufficient basis for the conclusion that has been drawn from them.

I have before me four pamphlets by Dr. Koch, dated severally

1841, 1843, 1845, and 1853. They relate to his discoveries in this country—the first two of them to his *Missourium*, and the others to his *Hydrarchos*, or, as these publications call it, his *Hydrargos*, or species of *Hydrachen*. The following are copies of their title-pages, commencing with the earliest:

"Description of the Missourium, or Missouri Leviathan, together with its supposed habits; Indian traditions concerning the location from whence it was exhumed; also, comparisons of the Whale, Crocodile, and Missourium with the Leviathan, as described in the 41st Chapter of the Book of Job; by Albert Koch. 16 pp. 8vo. St. Louis, 1841. [1840 on the cover, indicating that the copy is from a second edition.]

"Description of the Missourium Theristocaulodon (Koch), or Missouri Leviathan (Leviathan Missouriensis), together with its supposed habits and Indian traditions; also, comparisons of the Whale, Crocodile and Missourium with the Leviathan, as described in the 41st Chapter of the Book of Job; by Albert Koch. Fifth edition, enlarged. 23 pp. 8vo. Dublin, 1843. [A "third edition" of 24 pages appeared in London in 1841.]

"Hydragos, or Great Sea Serpent of Alabama, 114 feet in length, 7,500 lbs. weight, now exhibiting at the Apollo Saloon, 410 Broadway. Admittance 25 cents.—Description of the Hydrargos Sillimanii (Koch). A gigantic fossil Reptile, or Sea Serpent: lately discovered by the author in the State of Alabama, March, 1845. Together with some geological observations made on different formations of the rocks during a geological tour through the Eastern, Western and Southern parts of the United States, in the years 1844-1845; by Doctor Albert C. Koch, Corresponding Member of the Societies of Halle, and of Dresden, &c. 16 pp. 8vo. New York, 1845. [Following this, Dr. Koch published at Berlin, in 1845, a book of 99 pages, with eight plates, entitled 'Die Riesenthiere d. Urwelt,' giving an account of his Mastodontoid discoveries in America.]

"Description of the family of Animals now extinct, but known to the scientific world under the appellation of Hydrachen:* these animals, when living, were the most gigantic, powerful and horrible beasts of prey that ever ruled over and spread terror through the primitive Oceans; also

* In this change of name from *Hydarchos*, the *Water-Chief* (the suggestion, no doubt, of some friend, since he never wrote it right), to *Hydrachen*, a word that looks as if made up from the Greek word for *water* and the German for *dragon*, Dr. Koch evidently intended to adopt Müller's German term for the family, *Hydrarchen*.

an account of the discovery of the Zeuglodon Macrospondylus of Müller, and of the remains of Hydrachen in general; by Dr. Albert Koch, Corresponding Member of various Scientific Societies. 12 pp. 8vo. New Orleans, 1853."

The *first* of these pamphlets was printed when the Missourium was on exhibition at St. Louis in 1840–41; the *second*, when the skeleton was in Ireland, it having been taken to London in 1841; the *third*, when Dr. Koch's first collection of Zeuglodon remains was arranged and on exhibition as the "Hydrargos" in New York; the *fourth*, after his first Zeuglodon collection had been carried (in 1845) to Europe, and purchased (in 1847) for the Royal Anatomical Museum at Berlin (where it was studied by Müller); and after another "Hydrargos" had been obtained by Dr. Koch (in 1848), in the vicinity of "Washington Old Court House, Washington Co., Alabama," and had been transported (1) to Dresden (where, through "eight months' faithful labour," it was set up by May 6, 1849), and also (2) to Breslau, (3) to Vienna (1850), and (4) to Prague, and at each place put on exhibition; but not to Munich, because "the only saloon disposable was too small for the exhibition;" and, finally, had come back to its native country, "after it had established its just fame in Europe" as one of the "Hydrachen," and been put on exhibition in New Orleans.*

Still other accounts of earlier date are at hand in "Sill. Amer. Journal," vols. xxxvi. and xxxvii. of 1839; the *first* (vol. xxxvi., p. 198) cited from a newspaper article of January 1839, which was evidently written by Dr. Koch (then Mr., the title of Doctor appearing first in 1845); the *second* (vol. xxxvii., p. 191), signed "A. Koch, proprietor of the St. Louis Museum," and credited to the "St. Louis Com. Bulletin" of June 25, 1839.

Further, a note on the bones at St. Louis collected by Mr. Koch was presented to the American Philosophical Society, in October, 1840, by Dr. W. E. Horner, and an abstract from the Proceedings of that Society is cited in vol. xl. (1841).

It is evident from these documents that Dr. Koch was a man of enterprise, "an indefatigable collector." The credit is also due to him of having performed a great service to science by his collections; for these included one of the best skeletons of the Mastodon that has been unearthed, and two nearly complete

* The skeleton was on exhibition in St. Louis as early as 1855 or 1856, as stated in "Sill. Amer. Journal," II., xxi., p. 146, 1856; was there, as I learn from Dr. Lapham, sold to the Museum (Curiosity-shop); and thence, later, taken to Wood's Museum in Chicago, where it ended its remarkable career in the great fire of 1871.

skeletons of Zeuglodon, besides portions of other Mastodon and Zeuglodon individuals. Dr. Koch's "St. Louis Museum" contained, in 1840, according to Dr. Horner, "two hundred or more teeth of the Mastodon and American Elephant, a dozen or more lower jaws of the Mastodon, with very numerous specimens of other parts of the head and skeleton generally, though no perfect head;" "the skeleton nearly complete of a Mastodon;" and, besides, "the head of an animal which Mr. Koch calls nondescript," which Dr. Horner thought to be that of a Mastadon, and another interesting Mastodon relic, "denominated by the proprietor (Dr. Koch) *Missourium Kochii.*"

The two cases of the discovery of human remains along with those of the Mastodon, mentioned by Dr. Koch, are described in the pamphlets published in London and elsewhere abroad; in the "Transactions of the St. Louis Academy," vol. i. p. 61, 1857; and the *first* of the cases at an earlier date in a newspaper article of January 1839, cited in vol. xxxvi. of "Silliman's American Journal" (1839). This earliest account was written by Dr. Koch himself, the discoverer, for it is all in the *first* person; and, as it appeared within a few months of the discovery, it best deserves citation. It is therefore here republished, and after it, that of the *second* case, from the pamphlet of 1843.

I. "It is with the greatest pleasure the writer of this article can state, from personal knowledge, that one of the largest of these animals has actually been stoned and burned by Indians, as appears from implements found among the ashes, cinders, and half burned wood and bones of the animal. The circumstances are as follows:

"A farmer in Gasconade County, Missouri, lat. 38° 20′ N., lon. 92° W., wished to improve his spring, and in doing so, discovered, about five feet beneath the surface, a part of the back and hip bone. Of this I was informed by Mr. Wash (Walsh in pamphlet of 1843); and not doubting but the whole, or nearly the whole skeleton might be discovered, I went there and found as had been stated, also a knife made of stone. I immediately commenced opening a much larger space; the first layer of earth was a vegetable mould, then a blue clay, then sand and blue clay. I found a large quantity of pieces of rocks, weighing from two to twenty-five pounds each, evidently thrown there with the intention of hitting some object. It is necessary to remark, that not the least sign of rocks or gravel is to be found nearer than from four to five hundred yards; and that these pieces were broken from larger rocks, and consequently carried here for some express purpose. After passing through these rocks, I came to a layer of vegetable mould; on the surface of this was found the first blue bone, with this a spear and axe; the spear corresponds precisely with our common Indian spear, the axe is

different from any one I have seen. Also on this earth was ashes, nearly from six inches to one foot in depth, intermixed with burned wood and burned bones, broken spears, axes, knives, &c. The fire appeared to have been the largest on the head and neck of the animal, as the ashes and coals were much deeper here than on the rest of the body; the skull was quite perfect, but so much burned that it crumbled to dust on the least touch; two feet from this was found two teeth broken off from the jaw, but mashed entirely to pieces. By putting them together they showed the animal to have been much larger than any heretofore discovered.

"It appeared by the situation of the skeleton that the animal had been sunk with its hind feet in the mud and water, and unable to extricate itself, had fallen on its right side, and in that situation was found and killed as above described; consequently the hind and fore foot on the right side was sunk deeper in the mud, and thereby saved from the effects of the fire; therefore I was able to preserve the whole of the hind foot to the very last joint, and the fore foot all but some few small bones, that were too much decayed to be worth saving. Also between the rocks that had sunk through the ashes was found large pieces of skin, that appeared like fresh tanned sole-leather, strongly impregnated with the ley from the ashes, and a great many of the sinews and arteries were plain to be seen on the earth and rocks, but in such a state as not to be moved, excepting in small pieces, the size of a hand, which are now preserved in spirits.

"Should any doubts arise in the mind of the reader, of the correctness of the above statement, he can be referred to more than twenty witnesses, who were present at the time of digging." —*Sill. Amer. Journal*, 1839, xxxvi. p. 198.

The statements respecting this discovery in the pamphlet of 1843 agree in the main with the above. There is the additional information that the excavation took place in October 1838, and that the locality was within 300 yards of the Burbois (rightly Bourbeuse) River; but nothing is said of the "large pieces of skin that appeared like fresh tanned sole-leather strongly impregnated with the ley from the ashes," or of "the sinews and arteries" that "were plainly to be seen on the earth and rocks," portions of "which are now preserved in spirits."

II. "The second trace of human existence with these animals I found during the excavation of the Missourium. There was embedded, immediately under the femur or hind leg bone of this animal, an arrow-head of rose-coloured flint, resembling those used by the American Indians, but of a larger size. This was the only arrow-head immediately with the skeleton: but in the same strata, at a distance of five or six feet, in a horizontal

direction, four more arrow-heads were found; three of these were of the same formation as the preceding; the fourth was of very rude workmanship. One of the last mentioned three was of agate, the others of blue flint. These arrow-heads are indisputably the work of human hands. I examined the deposit in which they were embedded, and raised them out of their embedment with my own hands.

"The original stratum on which this river flowed at the time it was inhabited by the Missourium Theristocaulodon (and up to the time of its destruction), was of the upper green sand. On the surface of this stratum, and partly mingled with it, was the deposit of the before-described skeleton. The next stratum is from three to four feet in thickness, and consisted of a brown alluvium of the Eocene region, and was composed of vegetable matters of a tropical production; it contained all the remainder of the skeleton.

"Most of these vegetables were in a great state of preservation, and consisted of a large quantity of cypress burs, wood and bark, tropical cane, ferns, palmetto leaves, several stumps of trees, and even the greater part of a flower of the strelitzia class, which, when destroyed, was not full blown. There was no sign or indication of any very large trees, the cypresses that were discovered being the largest that were growing at the time. These various matters had been torn up by their roots and twisted and split into a thousand pieces, apparently by lightning, combined with a tremendous tempest or tornado; and all were involved in one common ruin. Several veins of iron pyrites ran through this stratum.

"The next over this formation was a layer of plastic clay of the Eocene region, also with iron pyrites; it was three feet in thickness. Over this was a layer of conglomerate, from nine to eighteen inches in thickness; over this a layer of marl of the Pliocene region, from three to four feet in thickness; next a second conglomerate, from nine to eighteen inches in thickness; this was succeeded by a layer of yellow clay of the Pliocene; over this a third layer of conglomerate, from nine to eighteen inches in thickness; and at last the present surface, consisting of a delta, or alluvial deposit, formed by the river, consisting of brownish clay, mingled with a few pebbles, and covered with large oak, maple and elm trees, which were, as near as I could ascertain, from 80 to 100 years old. In the centre of the above-mentioned deposit was a large spring which appeared to rise from the very bowels of the earth, as it was never affected by the severest rain, nor did it become lower by the longest drought."—*Dr. Koch's Pamphlet of* 1843, pages 13, 14 and 27.

The first question before us is: Whether the observations and

conclusions in the above statements may be accepted with confidence because made by a geologist, or a man of scientific training?

In the account of the second case above cited, Dr. Koch says that the Missourium was embedded in "a brown alluvium of the Eocene region," resting on the "upper green sand;" that next over it there was plastic clay of "the Eocene region" and beds of "the Pliocene region." He thus makes his Missourium to have come from the Lower Tertiary, and from a bed just above the upper green sand (Cretaceous), when actually from Quartenary beds; and he uses the term Eocene and Pliocene as if he had no familiarity with geological facts or language. The earlier pamphlet of 1840 avoids this bad geology, the "upper green sand" in that being called simply quicksand, and the other beds merely beds of clay and conglomerate. All the pamphlets sustain the conclusion that Dr. Koch knew almost nothing of geology, and that what he gradually picked up from intercourse with geologists he generally made much of, but seldom was able to use rightly.

In zoological knowledge he was equally deficient. The account of the Missourium, in the pamphlet of 1841, recognises a resemblance to the Mastodon and Elephant; but, notwithstanding this, it says that "his feet were webbed;" that he had "been without doubt an inhabitant of water-courses such as large rivers and lakes," as his webbed feet, solid bones without marrow, short and thick legs, flat and broad tail, &c., proved; that his curving tusks, 10 feet in length, "were carried by him almost horizontally [as represented on the cover of the pamphlet of 1843], so that it would be impossible for him to exist in a timbered country;" that his food (the teeth having before been described rightly as eight in number, "four upper and four lower") "consisted as much of vegetables as flesh, although he undoubtedly consumed a great abundance of the latter;" that he "*was capable of feeding himself with his forefoot, after the manner of the beaver or otter*;" and that he "possessed, also, like the hippopotamus, the faculty of walking on the bottom of waters, and rose occasionally to take air;" that "the singular position of the tusks* has been wisely adapted by the Creator for the protection of the body from the many injuries to which it would be exposed while swimming or walking under water; that it appears that the animal was covered with the same armour as the alligator, or perhaps the megatherium."

* The position which one chanced to be in when the Missourium was exumed. In the newspaper article by Mr. Koch, cited in "Sill. Amer. Jour." p. 191, vol. xxxvii., a Mastodon is reported as having been found with the tusk in this position, and Koch's "Missourium" is mentioned as a nondescript animal the head of which he found near the same place.

Later in the pamphlet he goes on with his conclusions, and says: "After having examined this subject in all its bearings, I have come to the conclusion that the *leviathan*—described in the 41st Chapter of the Book of Job—is none other than the Missourium here described, and from this time I shall call it the *Missouri Leviathan* (*Leviathan Missourii*)."

Next follows a comparison with the account of Job, taking up the several verses in order. On the first, "Canst thou draw out Leviathan with a hook?" he says: "The Missourium, as I have described, was a creature of enormous magnitude, ferocity, and strength, as well as fleetness in swimming: and by reason of his great weight and strength could attack the largest animals with impunity and overcome them with ease; nor is it probable that any combination of human force was able to draw him out of his native element." The sentence "Who can come to him with his double bridle?" has the following exposition: "The tusks coming out of the head until they arrive at a parallel with the nose, then turning suddenly back and forming a semicircle round the head (like a shield to prevent anything from approaching it), and measuring from point to point in a straight line over the head 15 feet; it can be seen at once how utterly futile would be any attempt to cast a bridle over him."

Dr. Koch closes this exposition and his pamphlet with a paragraph explaining how the "Leviathan, which is described as being an inhabitant of Asia, came to be found in the extreme west of the globe."

The Dublin pamphlet of 1843 shows some gain in knowledge; but the author still holds that the Missourium was not solely herbivorous; that its tusks curved outwards horizontally; that it "waded frequently at the bottoms of the former gigantic rivers and lakes of the west;" that "the ribs resembled more those of the Reptilia than those of the quadrupeds, being situated half reversed in the body [Dr. Koch's misplacement of them]; that is, the lower edge of the rib bends in towards the intestines, and the upper edge out towards the skin" (as stated *also* in the pamphlet of 1840); and he ends with the same detailed "comparison of the Leviathan with the Missourium," and the same explanation of how such an Asiatic inhabitant came to be found "in the extreme west of the globe."

Now this web-footed aquatic animal, capable of feeding himself with his forefoot, was no other than the *American Mastodon*, whose forefeet were as good for putting food into its mouth, or picking its teeth, as any elephant's. The specimen taken to England, in 1841, as the Missourium, and which Professor Owen says was "well-known to the public as the *Missouri Leviathan*, when exhibited with a most grotesquely distorted

and exaggerated collection of the bones in 1842 and 1843 in the Egyptian Hall, Piccadilly," is now (1846), he adds,* an almost complete skeleton of "the *Mastodon giganteus*, mounted in strict accordance with its natural proportions in the British Museum;" and a representation of it, copied from Owen, is the figure of the Mastodon on page 566 of the writer's 'Manual of Geology.'

It is pretty plain that Dr. Koch had not been trained to scientific investigation. This is equally obvious from his two pamphlets on the "Hydrargos."

(1) The skeleton exhibited in New York in 1845, and described in the pamphlet of that date, was 114 feet long, and this was at least 35 feet longer than nature—the vertebræ gathered by him in Alabama having been all strung together into one long "Hydrargos,' though belonging really, as Dr. Jeffries Wyman announced, to individuals of different ages, and, according to Müller, to at least two species (*Zeuglodon macrospondylus* and *Zeuglodon brachyspondylus* of Müller).

(2) The head was in part a piece of bad patchwork; Dr. Wyman stating in his notes, made after a careful examination,† that the cranium proper (the part over the brain) was made out of a single piece of bone without sutures, leading to the supposition that it was not the true cranium; an inference sustained, he says, by there being no foramen for the passage of the spinal marrow, and no larger space for the brain than that for the spinal cord on the upper side of some of the vertebræ; and by the amount of cement, which left little or nothing of the under surface in sight.

(3) The extremities of the so-called paddles were formed, says Dr. Wyman, of *casts of* "*a species of Nautilus*."

The Hydrargos or Hydrachen pamphlets hence do not require any modification of the opinion that Dr. Koch had not been trained to scientific investigation.

But on this point we have the opposing assertion of Dr. Koch. Being in a foreign country, where he had to make himself known, he opens his pamphlet of 1843 with the following introduction of himself to the public:

"Previous to my commencing this treatise, I wish particularly to mention that I have not only devoted the greater part of my life to the theoretical study of natural history, but have

* "History of British Fossil Mammals and Birds," by Richard Owen, F.R.S., &c., London, 1846, p. 298.

† "Proceedings Boston Nat. Hist. Soc.," 1845, p. 65. In Dr. Wyman's article, noticed by B. Silliman, jun., there is a figure of the remarkable head.

also made myself intimately acquainted with the practical part of it."

Still, we are unable to set aside the facts presented in the preceding pages and the opinion to which they have led, and therefore feel forced to take this introductory paragraph differently from what the author intended, and gather from it that Dr. Koch was a man of large pretensions. This same impression is conveyed by the account of his scientific travels in North America, which occupies the following six pages. I give an example. On the third of these pages he describes the era of the "mighty Missourium" and "ponderous Mastodon" as a time when, according to "every geological research," the earth's surface was "uninterrupted by any of the rough, broken, rugged deformities which now present themselves on every side," when "the climate was free from noxious vapours," and all was "delightful," &c.; and then dwells on the sudden dreadful change when "the ground was cursed for man's sake" and "all those gigantic creatures perished," and "the garden of delicious fruit trees and blooming flowers was converted into a gloomy forest of thorns and thistles." He also gives us his idea as to the nature of the great catastrophe, as follows: "The principal instrument used to cause this change, according to my views, was a certain comet that came in contact with our globe, which caused not only a different position of our earth, but also the interior fire and water to come into an immediate violent collision, which created a revolution, that naturally sought for vent, and therefore burst through the crust of the quivering earth, tore up countries, and sank them in the sea."

This is enough to prove that these pages do not sustain his large claim.

Holding, then, to the conclusion that Dr. Koch was quite ignorant of geology, and without scientific training, we are forced to doubt, to doubt strongly, his direct and definite statement that he had devoted the greater part of his life to "the theoretical study of natural history," and had made himself "intimately acquainted with the practical part of it." It is true that he knew about the earlier part of his own life better than any other person then living. Any way, he certainly overrated almost infinitely the results on himself of so prolonged study. This much we are disposed to allow in favour of his sagacity: that Dr. Koch appreciated the absurdity of the Leviathan story, and introduced it, after some thought about the people he was among, merely to get a full house for his Missourium; and that his attempted show of scientific knowledge had the same end in view. If this supposition is unjust to him, the other alternative explanation has to stand. In his New Orleans "Hydrachen" pamphlet (1853), the inside pages of the

cover contain a long-cited article* which makes the Zeuglodon the Leviathan of Job—thus showing apparently that his previous convictions were not too strong for a change of opinion, especially after the Missourium had turned into a Mastodon.

The special statements respecting the mode of occurrence of the human relics cited on pages 338 to 340 remain for consideration.

In the account of the deposits which afforded the Missourium, Dr. Koch speaks of "the present surface as consisting of a delta or alluvial deposit," which suggests a doubt as to whether the overlying beds of sand and pebbles may not have been of very recent formation through river action. It is not made certain that they were true Champlain deposits. He says that one arrow-head lay "immediately under the femur or thigh-bone;" and he further states, in his later article of 1857, that he "carefully thought to investigate" the point as to its having "been brought thither after the deposit of the bone," and decided against it. The observation and conclusion would have been more satisfactory had the author of them been a better observer.

The description of the deposits in Gasconade County, containing the remains of an animal "the principal part of which had been consumed by fire," is a still more unsatisfactory basis for a safe conclusion as to age. But in the article of 1857 he says that "the layer of ashes, &c., was covered by strata of alluvial deposits consisting of clay, sand, and soil from eight to nine feet thick, *forming the bottom of the Bourbeuse* [*River*] *in general*," which seems to make it almost certain that the beds were of quite recent origin. Neither in the account of 1839, nor of 1843, is the kind of animal mentioned; that of 1843 saying that "they were the remains of an animal which had clawed feet and was of the size of an elephant," and that "the construction of the foot [forefoot] shows that it possessed much power in grasping and holding objects;" but in that of 1857 he says "the bones were sufficiently well preserved to enable one to decide positively that they belong to the *Mastodon giganteus*."

The tragic part of the story—about the elephantine beast having been burnt alive by the Indians after they had used their bows, and also thrown more than a hundred and fifty great pieces of rocks "two to twenty-five pounds in weight" at him in vain—is an hypothesis in keeping with the rest of his documents. A fire kindled about the shoulders of a mired Mastodon would have taken long to get through the hide and

* It is headed "From the New York Evangelist," and must have been written in 1845, when the skeleton was on exhibition in New York City. The author's name is not given.

muscle so as to char the bones; and an Indian's appetite would have been pretty sure to have stopped the cooking short of this charring. The charring might have been done very long after the miring and death of the animal, and the facts be all as they are reported. The remark that "the greater portion of the bones had been more or less burned by fire" favours the idea that the fire was made about the bones at some time between the era of the Mastodon and the present time, and not about the living body.

The failure to repeat, in either of the later accounts, the early statements respecting the "large pieces of skin that appeared like fresh tanned sole-leather," and the "sinews and arteries plain to be seen on the earth and rocks," shows that he afterwards doubted and rejected this part of his observations; and this unavoidably suggests some doubt as to the other points; even to questioning whether the charring was not in fact only a blackening in colour due to burial in the marsh—a very common effect from such a cause; whether the crumbling was not a result of that natural decay which so generally befalls old bones; and whether the stone implements found were not small oblong stones of Nature's chipping or polishing.

Thus stands the evidence. If the statements respecting the deposits had been published by a good geologist with no more of detail, and without any special effort afterwards to make all things positive, there would be some room for doubt, considering the many chances of error that exist. But in the present case they were not made by a good geologist; they were not made by one trained to investigation, or to habits of precise statement; nor by one who had a knowledge of any department of science; nor by one whose sound common sense was so obvious a characteristic as to demand consideration for his opinions and statements; nor by one wholly free from pretence and sham.

Taking all things that have been reviewed into consideration, I think there is sufficient reason for regarding Dr. Koch's evidence of the contemporaneity of Man and the Mastodon as *very doubtful*. It is to be hoped that the geologists of the Missouri Geological Survey now in progress will succeed in settling the question positively.

The contemporaneity claimed will probably be shown to be true for North America by future discoveries if not already so established; for Man existed in Europe long before the extinction of the American Mastodon.—*Silliman's American Journal*, May 1875.

Since this article was printed I have come across another of Dr. Koch's pamphlets. It is a "second edition" of the New York pamphlet of 1845. In the main it is the same with the earlier one of that year. The most important difference is in the first half of the title-page, which reads as follows:

"Description of the *Hydrarchos Harlani* (Koch). (The name *Sillimanii* is changed to *Harlani*, by the particular desire of Professor Silliman.) A gigantic Fossil Reptile, lately discovered by the author, in the State of Alabama, March 1845."

A *second* difference is in the appended matter of nearly ten pages, which extends the pamphlet to twenty-four pages. This matter consists of (1) an extravagant article from "The New York Dissector;" (2) the article from "The New York Evangelist" about the Hydrarchos and Leviathan, alluded to on page 344, as occupying the inside pages of the pamphlet of 1853; and (3) a puff from "The New York Morning News."

A *third* novelty is a large wood-cut of the *Hydrarchos Harlani*, covering the last page of the cover. The body of the pamphlet contains only some verbal changes.

These New York pamphlets of 1845 contain one significant discovery of Dr. Koch's, made during his "geological tour," which is worth citing. He says: "When at Golconda, Illinois, I discovered a large deposit of old red Sandstone or Devonian system, in which I found a great variety of non-described fossil fish of most wonderful forms, the spiral columns of many of them bearing a striking resemblance to a screw, so that they are called by the inhabitants of the country *petrified screws*."

The Doctor's "spiral columns" of "fossil fish" are the common Bryozoan corals of the genus *Archimedipora*, found there, and elsewhere, only in Subcarboniferous rocks.

REVIEWS.

THE NORWAY FLORA.*

THE Flora of Norway is so far similar to that of the British Islands as may be broadly expressed by the general statements, that fully three-quarters of the species of vascular plants of the former are contained in the latter, and that the latter is richer to the extent of about 10 per cent. more than the former. The area of Norway, moreover, is but in a small proportion larger than that of Great Britain and Ireland. The difference between the two floras is, therefore, by no means considerable, nor are they unsuitable for comparison. England, no doubt, enjoys a larger share of the Continental flora than does Norway, and the West of England in particular produces some species of the north-west coast of France which are absent from Norway; while Norway, being partly within the Arctic circle, obtains many Arctic species which do not extend so far south as Scotland; Norway also includes a few species of the Alpine and North German floras which do not reach our country. "Blytt's Flora of Norway" may, therefore, be expected to prove highly interesting to us, especially since the descriptions of the critical species and sub-species appear to have been elaborated with much care and skill.

A few examples will suffice to illustrate the principal contrasting features of the two floras, so far as the volumes quoted above have permitted the necessary details. Of ferns we find in "Blytt's Flora" thirty-five species, of which only two are absent from us; while we have forty-five species as given by Professor C. C. Babington, or thirty-nine as given by Dr. J. D. Hooker. In sedges Norway is peculiarly rich, having, according to the "Flora," the large number of 102 species, against 70 as a full estimate of our species given by Babington. In grasses the two floras are nearly equal in number. In orchids Norway has thirty-one species, against forty-two in Britain.

The willows for "Blytt's Flora" have been specially monographed by Dr. N. J. Andersson, the principal authority on this difficult genus, who gives forty-four species, including crosses, while in Britain Babington gives only thirty-one.

In accordance with a common practice in local floras, and with the permissive rule laid down by Mr. Bentham, the descriptions of the plants in

* "Norges Flora; Forste Deel, af M. N. Blytt." Christiania, 1861. "2 den Del. 1ste Hefte, af Axel Blytt." 1874.

"Blytt's Flora" are given in Norsk, the vernacular language of the country. It would have been an uncommon and useful addition if the distribution of the species beyond the limits of Norway had been briefly indicated, as Mr. Bentham suggests should always be done in local floras of this nature. Thus, in the cases of the two non-British ferns, it might have been stated that *Asplenium crenatum*, Fr., occurs in Norway, Siberia, and Japan; and that *Struthiopteris germanica*, Willd. (oddly enough absent from Britain), is found in Europe from Scandinavia to Austria, in Asia from Manchuria to the Altai Mountains, and in North America from Canada to Pennsylvania.

As a recommendation to the book, at least for English students, it may be noted that the general arrangement of De Candolle's "Prodromus" (though reversed in order) has been followed, instead of one of the numerous so-called improved methods such as that employed by Hartman in his "Skandinaviens Flora." The first part begins with Equisetaceæ, and the portion of the second breaks off in the course of the Compositæ, so as to omit the tribe Chicoriaceæ; so far the whole number of species described, including some crosses in the genera *Salix* and *Cirsium*, is 637.

For the purposes of the flora Norway is divided into three parts; the first part contains all the country south of Dovrefjeld and east of the Langfjelds; the second contains the country between the watershed of the Langfjelds and the North Sea from the Naze to about 63° N. lat.; and the third contains all the country north of Dovrefjeld.

The distribution of the species is referred to five ascending zones: namely, the region of cultivation, the region of pines, the region of birches, the region of willows, and the region of lichens.

AMERICAN ZOOLOGY AND GEOLOGY.*

THE "Bulletin" (No. 2) contains an interesting monograph of the genus Leucosticte (Swainson), or the grey-crowned purple finches, including their history, biography, general characters, and geographical distribution. They are sparrow-like birds characterised by terrestrial habits, rosy tints to the plumage of the posterior portions of the body, and a fondness for the cold climate of high latitudes or Alpine elevations. The distribution within the United States is exclusively western, none of the species occurring eastward of the base of the Rocky Mountains, which region is their centre of abundance, but one of them occurs, in winter, from thence to the Pacific coast. The Alpine summits of Colorado seem to be the southern limit of their summer distribution, being restricted at this season to an altitude of 12,000 feet and upwards; the resident species, however (L. Australis) migrates chiefly to the base of the mountains, or about 3,000 to 6,000 feet lower. A paper by Dr. E. Coues on the family Geomyidæ gives the contrasting cranial and dental characters of the two genera Geomys and

* "Bulletin of the United States Geological and Geographical Survey of the Territories," Nos. 2 & 3. Second Series. Washington. 1875.
"United States Geological and Geographical Survey of Colorado, Report for 1873." By Dr. F. P. Hayden Washington. 1874.

Thomomys which compose it, and a comparison of the cranial characters of this family with the Saccomyidæ, in which, notwithstanding the close affinity of the two families, their crania are curiously different in general appearance and details of contour. A valuable synopsis is given of insectivorous mammals based on the relations of the study of the American forms and their comparison with those of other parts of the world, and preceded by a notice of the classification and views of the various authors who have written on this group. A report on the mollusca of Colorado concludes this number. No. 3 contains a topographical and geological report, including the mines of San Juan country, by Messrs. Wilson, Rhoda, and Endlich. From the report of the latter it appears that more than 4,500 square miles of the country is covered, in one continuous area, by volcanic rocks, the character of which throughout the district is one of extreme interest, demonstrating an enormous amount of activity during probably a short period of time, but which was, nevertheless, accompanied by a comparatively large number of changes in the chemical and physical qualities of the ejected material, and which consist mainly of variously coloured trachytes, sometimes with interstratified obsidian; these trachytes, of an aggregate thickness of 7,000 feet, forming the main mass of the volcanic rocks, are succeeded, but not continuously, by beds of rhyolite, dolerite, and basalt. With regard to the metallic lodes of the district, they appear to be, geologically speaking, young, probably having been formed at the close of the cretaceous or the beginning of the tertiary period, for they run through the trachytic rocks (which are supra cretaceous) in a very straight and regular course, either north-east to south-west or the reverse. The mines are but in their infancy, and the ores mainly found are galena, sphalerite, pyrite, chalcopyrite, fahlerz, and the variety freibergite. The same author, Mr. Endlich, contributes in the Report for 1873 a paper on the mining district of Colorado, with a catalogue of the minerals, including native tellurium, and the geology of the San Luis district, from which it appears that granitic and volcanic rocks constitute the two main systems of mountain ranges which traverse the country; a narrow band of silurian and carboniferous beds traverse the central portion of the districts in a south-easterly direction. Mesozoic and tertiary strata are found only along the eastern edge of the Front range, the cretaceous extending into the mountains in a few bays of ten to twelve miles in length, while the drift covers the San Luis valley and other portions of the district. Besides this paper, the report of more than 700 pages, with many plates, by Dr. Hayden shows the continued activity and labours of himself and his colleagues in the exploration of the district under his charge, from which much additional information of a detailed character is given of the geology, mineralogy, palæontology, zoology, and mining industry of the parts of Colorado surveyed during the past year. Dr. E. Cope describes the vertebrate fossils of Colorado, in which he briefly discusses the mutual relations of the cretaceous and tertiary formations of the West; a subject also alluded to by Professor Lesquereux, in his able and instructive paper on that debatable ground the lignitic formations of the West. They are referred by him to the tertiary period, although some cretaceous animal remains have been found with them. The tertiary aspect of the lignitic flora is undoubted, and their affinity to the tertiary flora of Europe; but they differ from the Dakota group below, from

which group upward there does not appear to be any trace of land-vegetation in the whole North American continent until we reach the lower lignitic formation.

A description of the new species of fossil plants is appended; the researches of the past year have added to the American tertiary flora about 100 species; the whole number now amounts to nearly 300. The reports in the volume on recent zoology are very full and include notices of the Alpine insect fauna, the geographical distribution of the moths, the diptera, coleoptera, neuroptera, and myriapoda, chiefly collected by Lieut. W. L. Carpenter in 1873, besides a report on the amphipod crustaceans by Mr. S. Smith, and a synopsis of the phyllopod crustacea of North America by Dr. Packard.

The volume with the concluding report on topography by Mr. T. Gardner is an important and valuable addition to the documents already published on the geology and geography of the western territories under the charge of Dr. Hayden.

THE MOLTEN GLOBE.*

THE views brought forward in this book as to the form of the continents of the globe are a further continuation and expansion of those given in a paper published in the "Edinburgh New Philosophical Journal" for 1857. It is to be regretted both for the reader and author that this is only the first part of the work, as the hypothetical ideas here expressed may without the other parts render its pages not very intelligible to every reader. The pyramidal form of the southern extremities of the continents has been remarked and discussed by Carl von Ritter Guyot, and other physical geographers, without any definite explanation. Again the different main direction of the two, broadly speaking, continental masses, the new and old worlds—one extended north and south, the other more in an east and west direction—are well-marked features. These bearings and the conical form of the southern lands seem to be at least partly influenced by the direction of the chief mountain ranges, as Professor Dana long ago pointed out with regard to the form of the North American continent. In his previous paper the author suggested the view that the pyramidal form of the outline of the southern extremities of the continents of the globe was the result of the conical superficial figure of the reliefs of the land entering the ocean at an angle to the spheroidal surface of the sea. Still more crystallographic as to the form of the land is the idea enunciated in the present part. Thus "a six-faced tetrahedron, supposed to be three-fourths covered by water attracted towards the centre of gravity of the figure, represents generally all continents and oceans on the globe in their actual relative positions. As there are four *acute* solid angles on the crystals, so there are four, and only four, continents or masses in relief on the globe; and as there are four *obtuse* solid angles on the crystal, so there are only four grand depressions or oceans on the globe." The author shows the astronomical and geological bearings on his tetrahedral

* "Vestiges of the Molten Globe." By W. L. Green, Minister of Foreign Affairs to the King of the Sandwich Islands. London. 1875.

theory of the figure of the earth's solid crust, and the physical connection between the tetrahedral figure and a molten spheroidal mass on which is forming a solid crust, and the partial deviation of the form of land to a presumed macling of the crystal, or a plane of lateral shift between the northern and southern hemispheres parallel to the plane of the ecliptic. The further explanation of these and other hypothetical views must, we think, await the publication of the second and third parts, when the author may endeavour to connect more in detail the earth's surface features with volcanic action and the tetrahedral collapse and shift of a thin crust upon the molten spheroidal nucleus.

CORALS AND CORAL-ISLANDS.*

PROFESSOR DANA has not taken the same length of time as Mr. Darwin in bringing his fine treatise to a second edition. Whereas the latter required more than thirty years, his American fellow-worker has taken but two in arriving at the second issue of his work. It is satisfactory to see that this work is in no way whatever controversial. Though we fancied when first we took it up that we should find considerable depreciation of Mr. Darwin in its pages, yet really nothing of the kind is to be found. It is true that on some points the author holds a view which differs from that held by the author of the "Origin of Species." But in every instance that he has to speak of Mr. Darwin, Professor Dana uses language which must gratify his opponent extremely, for, though not much later than our English *savant* in the field of exploration, he yet gives him the most extreme credit for the value of his labours.

The book does not require a lengthy notice, because of the fact that the present edition coming out so soon after its predecessor has not much in the shape of novel matter to offer its readers. Still we may in a general way sketch its contents. It first deals with polyps properly so called, which the author divides into three groups, and then treats of as living and dead agents. Next come the Hydroids, which we should hardly have expected in a work like the present. After them come two groups which we certainly think ought not to have been described in a book on corals, viz. the Bryozoans, which are, as of course the author admits, genuine mollusks—and the Algæ or nullipores and corallines. Lastly, the true coralline polyps—those which form such gigantic masses, or lagoons, on both sides of the equator, at about the latitude of 28°. Within this latitude the water ranges in temperature from 78° to 68°, being in some cases as much as 85° in the Pacific and 83° in the Atlantic, and descending in some rare instances, and for a limited amount of time, as low as 68°. Under this head of classification the author includes some twelve groups of corals, of which seven are inhabitants of the hotter and five of the colder climates. Then with a considerable

* "Corals and Coral-islands." By James D. Dana, LL.D., Professor of Geology in Yale College, &c. &c. London: Sampson Low, Marston & Searle. 1875.

degree of minuteness he describes the general features and different qualities of the reefs, classifying them as inner and outer. Next in order come coral-islands, in which he speaks of the forms and soundings and structure, and then he proceeds to give ample details concerning about thirty celebrated formations. Having treated of the islands he then comes to the question of the causes of coral-reefs, and here we have a lengthy discussion anent barrier, fringing and atoll reefs, the causes modifying their forms and mode of growth. This is just the point on which discussion will occur among those who have studied the subject: and we cannot help thinking that Professor Dana has given his arguments with a considerable amount of evidence in their support, and without any of that cavilling spirit of which we had to complain so bitterly when, some time since, the subject of glacier-motion was under discussion. Then follows a chapter on the geographical distribution of corals, and another also on changes of level in the Pacific. Finally comes a discussion on geological conclusions, in which the reader is treated to some observations on a host of subjects, of which the following are some of the more important:—Formation of limestones making thick strata of limestone; deep-sea limestones not of coral formation; absence of fossils from limestone strata; formation of dolomite and chalk; limestone caverns; oceanic temperature; and lastly, the oceanic coral-island subsidence.

The illustrations are most numerous, and are excessively well executed, those which form the frontispiece and are coloured being simply faultlessly beautiful. Many of them will be new to all but the special reader. In fine, we have to say a word of the author's style, which assuredly deserves the highest commendation. It is surpassed only by that of Mr. Gosse in those marvellous word-pictures of the lowly inhabitants of the ocean. But it is immensely superior to that of most writers on the subject: and it is so fascinating in its nature that it leads you away even over passages in which we think the average reader would otherwise fail to have any interest. We cannot do better than close this notice with a quotation from the preface to this excellent volume:—"Most agreeable are the memories of events, scenes, and labours connected with the cruise; of companions in travel, both naval and scientific; of the living things of the sea, gathered and moving by the ship's side, and made the study of the day, foul weather or fair; of coral-islands, with their groves, and beautiful life above and within the waters; of exuberant forests on the mountain-islands of the Pacific, where the tree-fern expands its cluster of large and graceful fronds in rivalry with the palm, and eager vines or creepers intertwine and festoon the trees, and weave for them hangings of new foliage and flowers; of lofty precipices richly draped, even the sternest fronts made to smile and be glad, as delights the gay tropics, and alive with waterfalls, gliding, leaping, or plunging, on their way down from the giddy heights, and as they go playing in and out among the foliage, of gorges explored, mountains and volcanic cones climbed, and a burning crater penetrated a thousand feet down to its boiling depths; and finally — beyond all these — of man emerging from the depths of barbarism, through Christian, self-denying, divinely-aided effort, and churches and school-houses standing as central objects of interest and influence in a native village." Thus the author gives

the reader a foretaste of the delights he is about to offer him, and there is not much of exaggeration in the picture. But there is another sketch which he draws of the opposite side, not so pleasant a picture it must be confessed, yet not wanting either in graphic sketches or in interesting episodes. Indeed, the whole book, while unsurpassed as a scientific memoir, is almost unequalled as a pleasant scientific treatise.

PHOTOGRAPHIC CHEMISTRY.*

WE think the author of this book has succeeded in producing a tolerably accurate and withal a popular treatise on the subject of photography, but we certainly do not think that greater results have been achieved. At the same time we believe that such a work was wanting, and that a considerable deal of good may be effected by its circulation among amateurs. We have many in this country who pursue photography as an amusement, and often with the very best artistic results, yet are extremely ignorant of the different applications of the science, or of the many wonderful attempts that have been made by its workers to apply it to perfect colour-painting. The author in his preface points out the many applications of which photography is capable. It is quite true that it brings before us pictures of nearly everything in the "heavens above and in the earth beneath," and we may soon expect it to work for us in the "waters under the earth;" "it registers the movements of the barometer and thermometer; it has found an alliance with porcelain-painting, with lithography, metal and book typography; it makes the noblest works of art accessible to those of slender means"—as witness the South Kensington photography of the masterpieces of Dresden and elsewhere:—"It may thus be compared to the art of printing, which confers the greatest benefit by multiplying the production of thought, for it conveys an analogous advantage by fixing and multiplying phenomena. But it does more than this. A new science has been called into being by photography, the chemistry of light—it has given new conclusions respecting the operations of the vibrating ether of light."

The author endeavours to give a popular sketch of the nature of photography, beginning at the very commencement. He describes and illustrates by a series of cuts and photographs the various processes which have to be gone through in the several operations. Then he describes the methods distinguished as portrait photography, landscape photography, levelling by photography, and photographing the heavenly bodies. He next deals with the several applications of photography, giving a brief chapter to each. It is in this department that we find most fault with his teaching, which we must confess seems to us of an exceedingly "popular"—using the word in the very worst sense—flimsy and imperfect character. Let us take one example—the chapter on micro-photography: in less than four

* "The Chemistry of Light and Photography in its Application to Art, Science, and Industry." By Dr. Hermann Vogel, Professor in the Royal Industrial Academy of Berlin. London: H. King & Co. 1875.

pages the whole subject is discussed, while Dr. Maddox's name is never once mentioned, although he is undoubtedly the first micro-photographer that England has produced. Then the description of the apparatus to be employed is evidently written by one who never endeavoured to take a microscopic photograph in his life. Still, however, we should remember that the author addresses the general and not the scientific public. And bearing that in mind, we would refer in conclusion to his chapter on "photography in natural colours." In this we have explained to us at some length the many difficulties that surround the subject, and the many partially successful efforts that have been made in this direction. It certainly does seem wonderful that an attempt in this way was made as long ago as 1810 by Professor Seebeck, of Jena, who found that chloride of silver took on the natural colours of the spectrum. Of course the main difficulty has been that of discovering a mode of fixing the colours, none being yet known. There is still work being done in this direction by M. Poitevin, of Paris; Herr D. Zencker, of Berlin; and Mr. Simpson, of London; and we may hope that future workers will discover a method of fixing these coloured representations. "The first attempts in uncoloured photography also failed for want of a fixing medium, which was only discovered seventeen years later by Herschel."

A MANUAL OF ELECTRICITY.*

ELECTRICITY has now become so important an agent and so generally employed in the arts and manufactures, that there certainly is required a work dealing with the whole subject *ab initio*, which those who desire to understand the subject might take up and read with advantage. We fear, however, that Mr. J. T. Sprague is hardly the person who could write such a book. It is a great mistake to suppose that a minute practical acquaintance with a subject is all that is requisite for a teacher; and we have no doubt that if this fact were once thoroughly recognised our publishers would have infinitely less to do than at present. But, unhappily, it too often happens that a man who thoroughly understands a subject is selected to teach it, without the possession of the slightest knowledge of how to impart his ideas. Now, such a case is that of the author of the present book. We do not doubt that Mr. J. T. Sprague is thoroughly qualified as a telegraphic engineer; but we certainly cannot recognise him as a teacher of science. His opening sentence is of itself quite sufficient to show that he is utterly unqualified to impart knowledge. What will any of our modern philosophers say to the following as the commencement of a work which proposes to teach practical science?—"When we endeavour to analyse and simplify our ideas of the universe of which we form part, we find that we reduce it to three distinct conceptions, which we define as essences or entities, viz. Matter,

* "Electricity: its Theory, Sources, and Application." By J. T. Sprague Member of the Society of Telegraphic Engineers. London: Spon. 1875.

Force, and Spirit." But enough of this. Practically the best part of the work is that which has to deal with electro-metallurgy. In this we find an ample explanation of the various processes; it extends to about fifty pages, and thoroughly compensates for the many deficiencies in the other parts of this volume. The dictionary of terms will also be found useful.

SACH'S BOTANY.*

ALTHOUGH we have waited for some years for the translation of this book, which was promised to us at an earlier date, we can now understand the many difficulties which attended the labours of the two distinguished botanists who have been concerned in the delivery of the English translation of this important work. And *imprimis* let it be distinctly understood that at the present moment it is not the intention of the Reviewer to do much more than notice the publication of the volume; for he has felt bound to put off his review of so voluminous and vast a work to the October number of this journal. And in order to justify his procrastination he must explain the fact that the book was not put into his hands till the month preceding the publication of this journal. He will, therefore, in the present instance merely proceed to indicate the general plan of the book, putting off his criticism to the later season. In the first place, we may observe that the Editors have endeavoured to bring the book up as much as possible to the times. And this they have done by having the fourth German edition for consultation ere they went to press with their translation, and also by inducing Professor Williamson, of Manchester; Mr. Sorby, of Sheffield; and Professor McNab, of Dublin, to come personally to their assistance in the preparation of chapters in which their own researches were especially referred to. Of the plan of the book, which we shall only speak of in this notice, the following may be taken as a *résumé*. It is divided into seven chapters, extending over a space of 850 pages of somewhat small but clear type, and of the largest 8vo. size. Thus it will be seen to be no small book. It is illustrated with more than 450 woodcuts intercalated with the text. In some few cases the cuts are repeated, and in almost all cases they will be absolutely new to the English reader; most of them are from Professor Sach's original drawing, and in all cases where they are borrowed from other workers there is the somewhat unusual honesty exhibited of stating from whom they have been borrowed. Of the seven chapters of which the work is composed the following are the titles, each of which is subdivided into a number of sections, and the whole of which are included in the three sections into which the book is divided, viz.:—*General Morphology, Special Morphology*, and *Physiology* :—1st, morphology of the cell; 2nd, morphology of the tissues; 3rd, morphology of external conformation of plants. Then

* "Text-book of Botany, Morphological and Physiological." By Julius Sachs, Professor of Botany in the University of Würzburg. Translated and Annotated by A. W. Bennett, M.A., B.Sc., F.L.S.; and W. F. T. Dyer, M.A., B.Sc., F.L.S., Oxford: Clarendon Press. 1875.

commences Book II., which has to do with special morphology; and lastly comes Book III., which has the following chapters:—1st, the molecular forces in the plant; 2nd, the chemical processes in the plant; 3rd, the general conditions of plant life; 4th, the mechanical laws of growth; 5th, the periodic movements of the mature parts of plants, and movements dependent on irritation; 6th, the phenomena of sexual reproduction; and 7th, and lastly, the origin of species. Of these several chapters we shall be more prepared to speak at the period of our next notice.

A HISTORY OF THE AMERICAN INDIANS.*

THE labour that has been undertaken by Mr. Bancroft, the author of the two splendid volumes now before us, was indeed a vast one, one which alone a person who devoted wellnigh a life to it could have at all achieved. And if the author has not been completely successful we are sure that few critics will be so singularly ungrateful as to condemn the work on that account alone. If we for a moment consider the vastness of the region proposed to be explored—extending from the Pole to the Equator—the immense library of books that a writer on the subject must have to examine, and the physique which an investigator of such a subject must be possessed of, we are the more astonished that so much good work should have been done, than that so little has been acquired. Mr. Bancroft has set himself down to give us an accurate account of all the races, civilised and savage, of the American Indians, and he has, we think, discharged the duty he has undertaken with remarkable fidelity, and with an absence of that tendency to theoretical disquisition so common in all who have to discharge similar duties. When we further consider that the extent of surface of the earth covered by the races he has dealt with in these volumes is nearly one-tenth of the entire globe, we shall have some idea of the vastness of the labour; and we are compelled to admit the force of the author's observation, that the labour of preparing these two volumes is equivalent to that of one man working continually for at least ten years. Let us see how this labour was discharged. Mr. Bancroft found that the information relating to these numerous tribes was diffused through no less than 1,200 volumes in different languages, of which he has given an accurate list, with their dates and places of publication. How, then, were these to be sifted, with a view to collect the grains of truth from the chaff of fable and unreality? It is thus explained:—"In the work of selecting, sifting, and arranging my subject-matter I have called in the aid of a large number of assistants; and while desiring to place on no one but myself any responsibility for the work, I would render just acknowledgment for the services of all." Which he then proceeds to give. To do more than point out the general plan of the work would be here completely out of place. And this we shall now

* "The Native Races of the Pacific States of North America." By H. H. Bancroft. Vol. I. Wild Tribes. Vol. II. Civilised Nations. London: Longmans & Co. 1875.

proceed to do. After some general observations he proceeds to deal with the wild tribes, as follows: First, the Hyperboreans, then the Columbians, Californians, New Mexicans, wild tribes of Mexico, and lastly the wild tribes of Central America. Under each of these heads, besides treating of the several groups of Indians—as the Aleuts, Nootkas, Chinooks, Salish, Sahaptins, Modocs, Eurocs, Hoopahs, Sonomas, Shoshones, Apache, Pueblos, descendants of the Aztecs, Hueztecs, Tzotziles, Chochones, Mosquitos, Caimanes, Viscitas, and nearly a hundred other tribes—he deals with their respective climates, country, dress, dwellings, food, weapons, boats, government, domestic affairs, amusements, diseases, burial, laws, and medicine. And under these several heads we can promise those who are in the slightest degree interested a mass of facts stated on good authority, and relating some of the most peculiar customs we have yet had an opportunity of learning. The laws especially relating to marriage and to the perpetration of certain crimes connected with sex are most astonishing, the more so as they display a tendency toward the offences of a luxurious civilisation. Indeed, the reader of Sir J. Lubbock's last book on Man will find in this, the first volume, a vast deal to interest him.

In the second volume Mr. Bancroft deals with the civilised nations of the same district of America. And in this we find much to interest us as to the civilisation of the Aztecs, Nahua, and Mayas nations, more especially in regard to the palaces, zoological gardens, wardrobes, harems, priesthood, slaves, public festivals, dress, and commerce of those singularly interesting groups. We think that there can be little doubt that the author's view regarding the people at the time they were conquered by Spain, is in the main perfectly correct. He holds that they possessed a degree of civilisation infinitely superior to that of their Spanish conquerors, and he thinks that their extermination is due entirely to the abominable cruelties practised on them by those who overran the country. There are few faults to be found in these volumes. And it is possible that one of our objections may be met by the author's love of accuracy. We refer to the constant display of notes from Spanish writers given in their own language. The number of readers in this country who are versed in the language of Spain is exceedingly few, and therefore we fear many interesting passages will be more obscure to them than if they were actually in the Hebrew tongue. The author too is rather in error in stating Mr. Darwin's theory. Evidently Mr. Bancroft is no naturalist, or he would not have imagined that the development of worms [insect-larvæ] in meat could be looked on as a proof of the doctrine of evolution. But this is a matter of little moment. In reading his book we have been extremely interested, and we can fully appreciate the labour its preparation must have cost him; and we look with curiosity to the publication of his further researches on this absorbing subject.

TRESPASSERS.*

ONE often wonders at the ingenuity exhibited by the Rev. J. G. Wood in giving a series of successful titles to his books on natural history. And here is another instance. One would surely have thought that in the many works—some of them extremely interesting—which the author has brought before the public, he must have described the habits of the animals with which he deals in the present volume. But, be that as it may, we have here treated in a new fashion those members of the animal kingdom which may be distinctly called the robber class, and which leave their own area for a time to search for food in the department of the earth that belongs to other creatures. And Mr. Wood is, for the general reader interested in natural history, a most charming companion. He has acquired a very pleasant style of writing, and he is moreover tolerably accurate in his statement of facts, while at the same time he explains difficulties without the use of technicalities where they can be avoided. His pictures are exceedingly well executed. Of course, in the illustrations to such a book as the present a good deal of latitude is allowed to the engraver, who has to put a number of creatures together which are never seen in company unless at the Zoological Gardens, and who has to arrange them gracefully for the cut, without the least regard to their natural habits. But, if we make allowances of this kind, the twenty-six page-plates—though some of them are merely woodcuts printed in separate pages—are excellent of their kind, and exhibit the habits and character of the animals in the most forcible manner. The matter of the book is most instructive to the non-naturalist reader; and although here and there we observe conclusions stated—as, for instance, that concerning the function of the Eustachian tube—with which we cannot possibly agree, still it must be inferred that Mr. Wood has again in the present instance succeeded in producing a most pleasant and profitable work.

URE'S DICTIONARY.†

THIS, the seventh edition of a most useful work, is the second of the series which has been noticed in these pages. And we note that the work is in many respects materially improved. In the first place, as to the plan, now pursued, of printing the title of each article in a solid black type. This mode was not adopted in previous editions of this work, which we often wondered at, the more so as it has been adopted for years in "Brande's

* "Trespassers: showing how the inhabitants of the earth, air, and water are enabled to trespass on domains not their own." By the Rev. J. G. Wood, B.A., F.L.S. London: Seeley, Jackson & Halliday. 1875.

† "A Dictionary of Arts, Manufactures, and Mines, containing a clear Exposition of their Principles and Practice." By Robert Hunt, F.R.S., assisted by F. W. Rudler, F.G.S.; with 2,163 illustrations. 7th edition, in 3 vols. London: Longmans. 1875.

Dictionary," which is published by the same house. It greatly enhances the value of the work, for it renders the labour of the consulter of the dictionary infinitely less than it used to be. We regret to learn that the present editor, Mr. Hunt, was so seriously ill during the preparation of the new edition; but we must compliment him and his assistant, Mr. Rudler, upon the general excellence of the several articles. Of course these gentlemen are only responsible for some of the very valuable contributions which fill these three portly volumes. Of others we may mention the names of a few of the more distinguished—Professor Frankland, Mr. Bristow, Mr. Binney, Mr. Warrington Smith, Dr. Noad, Dr. Angus Smith, Mr. Greville Williams, Professor Voelcker, Mr. C. V. Walker, &c., &c. Some of the articles are of special excellence, such as those on "paper manufacture," "nature-printing," "thermometer," "mint," "leather," "Silber lamp," "disinfectant," "woollen manufactures," and "mining." Of these the last is perhaps the best and fullest. But others—as, for instance, those on woollen manufacture, disinfectants, and paper manufactures—are also particularly good and clear *résumés* of the branches to which they relate. The type remains—with the exception already stated—the same as in the former editions, although, as the editor alleges, it has been re-set. So far as we have read the articles seem excellent.

THE BORDER-LANDS OF INSANITY.*

WE trust that all those who are at all interested in insanity will procure Dr. Wynter's book and carefully read it. Two chapters—that entitled "The Border-lands of Insanity," and that styled "Non-restraint in the Treatment of the Insane"—are in themselves alone sufficient to awaken the mind to some of the many cases of incipient insanity that daily surround us, and of the causes that determine this condition in many who would otherwise pass through life without a trace of mental disability. Further, they show us how abominably, shockingly cruel have been some of our own physicians who have had to deal with insanity even within the last half-century. Dr. Wynter writes in a most pleasing style, and his book swarms with anecdotes which too truly tell the tale that he wishes to convey. We took up the book fancying that we should find it a useful summary of the facts that indicate approaching insanity, but we have found it far more than this. And we have been fascinated by the author's style and his happy mode of illustration, and we have laid down the book fully impressed with the idea that if widely read it cannot but effect grave changes in our treatment of even the less noticable cases of insanity.

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* "The Border-lands of Insanity; and other allied papers." By Andrew Wynter, M.D., M.R.C.P. London: Robert Hardwicke. 1875.

Annual Record of Science and Industry for 1874.—Edited by Spencer F. Baird, with the assistance of eminent men of science. London: Trübner & Co. 1875.—The present issue of this work appears an improvement on those that have gone before it. Still we do not fancy that such a book will command a large sale. In fact, we do not know who would be likely to purchase it. Not the worker at any kind of science, for it would be useless to him; and we imagine that it would be hardly of interest to lovers of popular scientific research. We think that Mr. S. F. Baird has done his work well.

Arithmetic in Theory and Practice. By J. Brook-Smith, M.A., LL.B., 2nd edition. London: Macmillan. 1875.—This seems a good and clear book. The author evidently takes considerable pride in his work, which has been done lucidly and comprehensively. The addition of so many examination papers is decidedly of advantage.

Reliquiæ Aquitanicæ: being contributions to the Archæology and Palæontology of Périgord, by E. Lartet and H. Christy. Edited by T. Rupert Jones, F.R.S., etc. London: Williams & Norgate. May 1875. This number, which promises to be the last but one, is occupied by two very interesting papers. The first is by Professor Milne Edwards, of Paris, and is upon the bones of birds from the South of France caverns. The second is by Dr. E. T. Hamy, on some bones of a fossil man that have been obtained from Le Madelaine; it is a short but a good contribution, and it is illustrated by a splendid plate, done in the very best Paris style, and giving several representations of the bones.

We have received the following: "An Introduction to Logic and Metaphysics," by T. S. Bassett, F.L.A.S.—"On certain Theories of Solar Structure," by S. P. Langley.—"Our Barren Lands," by General W. B. Hazen. A capital account of the barrenness of certain parts of America that are represented by emigration agents as flourishing portions of the New World. —"English Hospitals in their Sanitary Aspects," by G. Buchanan, M.D.— "Recreative Science: a Plea for Field-clubs and Science Associations," by D. Page, LL.D.—"Geological Evidences of the Antiquity of Man," by T. Karr Callard, F.G.S.—"The Patent Question in 1875," by R. A. Macfie. —"The Potato Disease, etc.," by E. Haigh.—"Inaugural Address of the Psychological Society," by Mr. Serjeant Cox.—"Sixth Annual Report of the Board of Health," Massachusetts, U. S. A.—"The Law of Inheritance; or, the Philosophy of Breeding," by E. L. Sturtevant, M.D.—"Aerial Locomotion," Pettigrew and Marey, by Professor Coughtrie.—"The Transit of Venus: its Meaning and Use," by T. H. Budd, F.R.A.S.

SCIENTIFIC SUMMARY.

ASTRONOMY.

THE *Astronomer Royal's Annual Report.*—The Report delivered this year by Sir G. Airy to the Greenwich Board of Visitation is noteworthy for remarks apparently of a valedictory nature. It is impossible to read the summary of the work done during the Astronomer Royal's forty years' tenure of office without feeling that the time is drawing near when he proposes to retire. "The report," he says, "which I have now read is the fortieth of its class which I have had the honour to lay before the Board of Visitors. During the time to which they apply the constitution of the Observatory, personal and material, has been greatly changed. Only one member of the Board of Visitors, I believe, remains as witness of my first proceedings. There is not now a single assistant or a single instrument in use (for even Shuckburgh's equatorial is not employed as a graduated instrument) of those which formed the establishment of 1835. The contemplation of this long period and of these changes induces me to look backward and forward on the objects of the Observatory and the mode of carrying them out." After sketching the past history of the Observatory, and describing the work carried out during the last forty years, the Astronomer Royal proceeds thus:—"Turning now from the past to the future, I see little in which I could suggest any change. If it should ever be necessary to make any reduction, I should propose to withdraw meteorology, photoheliography, and spectroscopy, not as unimportant in themselves, or as ill fitted to the discipline of the Observatory, but as the least connected with the fundamental idea of our (*sic*) establishment. In the nature of addition, I will indicate one practical point. I much desire to see the system of time-signals extended by clocks or daily signals to various points of our great cities and our dockyards, and, above all, by hourly signals on the Start Point, which I believe would be the greatest of all benefits to nautical chronometry. Should any extension of our scientific work ever be contemplated, I would remark that the Observatory is not the place for new physical investigations. It is well adapted for following out any which, originating with private investigators, have been reduced to laws susceptible of verification by daily observation." We cannot very warmly commend the tone of these suggestions for the future. They correspond, however, to the views which have been habitual with Sir G. Airy for many years past, and which are natural when the origination of new ideas has become to some degree a labour and a toil. It is so much easier to

direct a number of assistants to do daily such and such work (suggested by private investigators) than to guide a scheme of operations, noting the results obtained, and modifying gradually the method of procedure until at last some great scientific truth has been educed. We should be unwilling, were not scientific interests too manifestly at stake, to indicate in this way the signs and effects of the want of originating power which necessarily (at any rate, almost invariably) shows itself with advancing years. But the point is one which will have to be noted before long, if this country is to advance as rapidly in scientific matters as it might do. It is not necessary to draw unpleasant comparisons between the Astronomer Royal's views and those, say, of the younger chief of the Washington Observatory. It will suffice to compare his present views with those he held eighteen years ago. *Then* (see Report to the Board of Visitors, 1867), speaking of a proposed addition to mere routine work, he said: "Whether the result will be to add millions of useless observations to the millions already existing, or whether something useful may be expected to result, I cannot hazard a conjecture," a remark which De Morgan justly characterised as a "conjecture and a very obvious one;" showing that "Mr. Airy would not have given 2¾*d.* for the chance" of a useful result. *Now*, routine observations alone are recommended.

This leads us to make a few remarks on certain reports which are abroad as to the successor whom Sir G. Airy and some of the Admiralty officers wish to see appointed. There is one name which every one would expect to hear. One astronomer, trained in observatory work, practised as an observatory chief—two essential points—is also distinguished in England and abroad as *facile princeps* among English mathematical astronomers. Many will be surprised, and not a few will be pained, to learn that that great astronomer is not (it is said) selected, so far as the selection depends on the present Astronomer Royal; but another, a most estimable, energetic, and able man, but comparatively unknown. Now apart from the injury inflicted on English astronomy, if our greatest mathematical astronomer since Newton should thus be passed over, we would point out that irreparable mischief will be done to Sir G. Airy's reputation (which Englishmen value highly) unless this rumour should be proved by future events to have been ill-founded. Assuming that the eminent astronomer indicated will honour the office by accepting it, if he should be passed over (in favour of any man soever) every one will conclude either that Sir G. Airy was unwilling to be followed in office by an astronomer more eminent than himself, or that the grave injury which (unwittingly, but very really) he inflicted on that astronomer thirty years ago rankles still in his remembrance, as injuries inflicted on others are too often apt to do. We trust, however, that the rumour will prove to be wholly without foundation.

Eclipse of April 6.—In the last Summary we pointed out the fact that the arrangement proposed by the committee of the Royal Society for observing this eclipse could not possibly lead to any useful result, simply because faint light of small chemical activity was expected to do work which stronger light of greater chemical activity had failed to do, in the same time. Nature not being apt to vary her laws even to oblige committees, the result has naturally been that the expedition sent out under

the auspices of the R. S. Committee has resulted in absolute failure. We hope (but, judging from past experience, we scarcely expect) that the lesson which this result ought to teach will be learned and remembered.

Photography in the Transit of Venus.—A discussion has arisen as to the best way of photographing Venus in transit. In reply to objections raised by Capt. Abney to the American or long-focal system, Mr. Proctor, in the Notices of the Astronomical Society for April, makes the following remarks: "The American Transit Committee, after many experiments and long inquiry, came to the conclusion that the diameter of the Sun, as depicted by the photoheliograph, could not be ascertained (at least with the extreme accuracy necessary for determining the solar parallax) either by calculation (depending on the optical adjustments), or by direct measurement, or by any practical contrivance, such as photographing a scale. On the other hand, they consider that reliance can be placed on the calculated scale of a picture taken at the principal focus, while the centres of the discs of Venus and the Sun can be determined accurately, because each centring results, not from a single pair of measures, but from as many all round each limb as the observer may wish to make. Of course the position of the centres may be determined in the same way, from a photoheliographic picture; but no advantage results if there is no trustworthy scale of measurement. This, then, is the point at issue, viz. whether a trustworthy scale can be obtained. The available methods are (i) calculation, (ii) measurement of the pictured solar diameter, and (iii) photographing a scale. As to the first, I apprehend that there can be no comparison in point of exactness between the calculated scale of a picture at a principal focus and that of a picture optically enlarged: it is only necessary to consider the optical adjustments and relations involved, to be assured of this. As to the second method, it matters little whether photographic irradiation be large or small; for at the lowest estimate ever yet made, the effects of irradiation must be fatal in such a problem as determining the solar parallax: apart from this, we now have evidence showing that the photographic sun is really larger than the optical sun. As to the third method, it seems sufficient to note that the use of a photographed scale introduces of itself a probable error as large as that in single measurements of the photographed disc of the Sun or Venus; and such an error would be fatal in a problem of this kind. The fact pointed out by Capt. Abney that daguerreotypes 'are subject to much greater fluctuations of expansion than are glass negatives,' seems to counterbalance the superiority claimed for them (by Sir G. Airy at the January meeting) in point of definition. It may be hoped that before the Transit of 1882 photographers and astronomers will have decided on some one method of photographing Venus in transit. The qualities of the various methods employed on the present occasion will be sufficiently indicated during the examination of the complete series of transit observations. One point seems already clear, viz. that contacts determined from photographic records differ from contacts observed with the telescope, the photographic sun being larger than the sun we see. Hence greater reliance will probably be placed on mid-transit photographs. This country is afforded a noble opportunity of serving science by providing Southern stations for this purpose in 1882—an opportunity of which it may be hoped that she will avail herself."

In a reply to these remarks, Mr. Christie, chief assistant at Greenwich, makes the somewhat startling assertion that the diameter of Venus is as much diminished by photographic irradiation as the diameter of the sun is increased, and that therefore the sum of the diameters is not affected at all. But it cannot be admitted that the diameters of Venus and the sun are affected to the same degree by photographic irradiation. The blackness of Venus and of the sky round the sun may be equal, but the brightness of the sun near the limb is very inferior to the brightness near the centre. This familiar fact somewhat weakens Mr. Christie's argument. But, to say truth, no one who has studied a photographic picture of the sun can compare the definition of the limb even with the definition of a sun-spot, far less with that of a planet in transit. The appearance of the projected image of the transit of Mercury, in November 1861 and 1869, corresponded precisely with the appearance depicted in photographs.

Dr. Rutherfurd, in Part I. of "Papers relating to the Transit of Venus in 1874," * says: "The photograph of the sun will have a greater or less diameter *by many seconds of arc*, according to the energy of the rays which have produced the image; and this discrepancy may be produced by a change in the aperture, in the length of exposure, in the transparency of the atmosphere, in the hour of the day, or in the sensibility of the chemicals." To assume that the diameter of Venus will be affected in precisely the same degree, notwithstanding the marked difference in the conditions, seems somewhat unsafe. In the same series of papers all the points recently raised in defence of the photoheliographic method and against the long-focal method have been fully considered.

Bright Arc seen round dark Limb of Venus in Transit.—Mr. Russell, Government Astronomer at Sydney, has obtained photographs showing the bright arc seen around the dark part of the disc of Venus between the epochs of external and internal contact. At the meeting of the Astronomical Society in May, after describing this appearance, he expressed doubts whether the bright arc is really due to the refractive action of Venus's atmosphere, because that action would disperse the refracted light between the earth and the sun. This is true of the totality of light so refracted, but it does not affect any small pencil of light such as the observer's eye or telescope could receive. In fact, the same reasoning would show that the sun, as seen by us after geometrical sunset (that is, when a straight line to the sun's upper limb is truly horizontal), ought not to be seen, because the air is refracting the solar rays divergingly.

Diameter of Venus, from recent Transit Observations.—Colonel Tennant, from an examination of the recent transit observations, gets the following result as to the dimensions of Venus:—

Mean semi-diameter at mean distance . 8·″4518 + 0·″0008

The following determinations had previously been obtained:—

Encke, from transits of Venus	8·″303
Airy, measures on meridian	8·283
Main, micrometer (double image)	8·775
Stone, measures on meridian	8·472
Plummer, micrometer (double image)	8·661
The value used in the American Nautical Almanac	8·546

* Published at Washington in 1872.

On the Star 61 *Geminorum.*—Mr. Webb makes the following remarks on this star:—"The star known as 61 *Geminorum* was entered in the Bedford Catalogue as double, 7½ and 9 magnitudes, with a position-angle of 110° and a distance of 60″, the colour being recorded as deep yellow and yellowish. I examined it with a $3\frac{7}{10}$-inch achromatic, March 23, 1852, and entered it 'white, single.' There could be little doubt as to its identification, from the neighbourhood of the double star ℍ III. 48. February 14, 1855, having taken pains as to its identification, I again found it, with the same instrument, single and white. I noticed, however, on this latter occasion an exceedingly minute star, not above 11 mag., which might agree as to distance, but with a very roughly estimated angle of 185° or 190°. In 1861 and 1871 the *comes* was invisible to Mr. Knott, with all the advantage of a 7⅓-inch Alvan Clark object-glass. I believe I have never looked for it since, but have been lately interested by finding that it has been recovered this spring by Herbert Sadler, Esq., of Honiton Rectory, the extreme acuteness of whose vision, in the use of a 6½-inch silvered mirror by Calver, is attested by his recognition of several most delicate and difficult objects. He gives it only 12·5 mag. at about the right distance, but with an estimated angle of 160° to 165°. It seems, therefore, probable that, unless we can suppose an error in the figure expressing Smyth's magnitude, we have here a variable star, which it would be desirable to examine closely, and with instruments capable of giving a definite value to the angle of position. The possible change of colour also in the principal star merits attention. My own 9⅓-inch speculum being at the present time dismounted, with a view to the ultimate perfection of its figure, though previously very good, I am unable to contribute any information on the subject."

Monthly Notices of the Astronomical Society.—The poverty of these recently has been so remarkable as to merit a passing word of comment. With the expectation of securing for these papers something better than mere burial at the Society's rooms, they were made purchasable by the public, as issued, at a shilling per number. But the Society can hardly expect to find any considerable number of persons, however interested in science, willing to pay the price of a good monthly magazine for some thirty pages of matter, most of which, for any value it has, might as well have remained in the Observatory note-books from which it would seem to have been extracted. In the last two numbers there are not ten pages of the least scientific value or interest. One or two valuable but short mathematical papers from the editor, three or four very short papers relating to the recent transit, and a few remarks on double stars and a star of large proper motion, are all that even the Fellows of the Society can be supposed to care for. The scientific public ought to be considered, or else each number ought to be priced according to its value. Threepence, for instance, instead of two shillings, might fairly have been asked for the last two numbers together. The matter is more serious than many suppose; for very general interest might be drawn to the proceedings of the Astronomical Society, and thus to astronomy itself, if an effort were made to make the monthly numbers more attractive. It is, however, nobody's business, and therefore nobody (of late, at least) seems to have cared to do it. Moreover, if any Fellow of the Society who has got himself elected to the Royal Society has anything

of real interest to say on astronomy, he does not communicate it to the Society specially devoted to astronomy, but to the Royal Society. If half-a-dozen students of astronomy would resolutely, and for a good while together, stand by the Astronomical Society, sending abstracts only of their results to the Royal Society, astronomy would gain largely; but we fear there is no chance of this, the mischief which exists being itself the cause of the continuance of a mischievous system.

The Planet Saturn.—This planet will be in opposition to the sun on August 16th.

Annular Eclipse of the Sun.—There will be an annular eclipse of the sun on September 29, visible as a partial eclipse (between 11h. 25m. and 12h. 47m. at Greenwich), only 119 thousandths of the sun's diameter being concealed.

BOTANY AND VEGETABLE PHYSIOLOGY.

The Lecythidaceæ.—Professor Asa Gray, in noticing the large memoir on this subject which the Linnæan Society has recently issued, says ("Silliman's American Journal") that it is a splendid memoir, of 64 pages and 33 plates, large quarto, forming the second part of the 30th volume of the "Transactions of the Linnæan Society," 1874, a wonderful piece of work for a man of Mr. Miers' great age. He proposes to restore the Lecythideæ or Lecythidaceæ as an independent order. The plates illustrate the floral structure of the twelve genera which the author recognises, and the fruits of most of them. It is a remarkably interesting group, consisting of huge trees, all tropical American, with singular flowers and large woody fruits, a sort of pyxis, containing numerous nut-like seeds, of which Brazil-nuts (from *Bertholletia excelsa*) and Sapucaia-nuts (from a species of Lecythis) are well-known examples. Few botanists have had the opportunity of properly studying these noble plants, and no one has devoted to them so much attention as the veteran Miers.

The different Parts of a Floral Whorl, which are by no means well put forward in our text-books, have been recently pretty fairly put before the reader. Dr. Eichler, of Kiel, has (according to "The Academy," May 8) recently published the first part of a work entitled "Blüthendiagramme," in which he illustrates the inflorescence and flowers of all the monocotyledonous and dialypetalous dicotyledonous families of which he has been able to examine sufficient material. The actual and theoretical diagrams of most of the different modifications of arrangement are given, and botanists will find it a very useful book; but in its German form it must remain unintelligible to many. The theoretical diagrams of many of the monocotyledonous families, such as the Gramineæ, Cyperaceæ, Centrolepideæ, &c., are very interesting, and in all cases there are copious references to existing literature. To complete the symmetry of the flowers of some groups involves much labour; hence it is not surprising that there are many blanks, and that much diversity of opinion still prevails regarding the nature of some structures. The relative dignity, as it is termed, of the different organs of a flower is

still a debateable point, and therefore many of the diagrams would require modification to suit different views.

Enlargement of the Kew Buildings.—We learn from a contemporary that a new building will probably be erected at Kew to receive the national botanical library and the immense collections of dried plants at present deposited in a house which is too small and otherwise very inconvenient for purposes of study. The value of the collections at Kew to working botanists cannot be over-rated, and the admirable manner in which they are arranged is beyond all praise. There may be some difference of opinion as to the desirability of amalgamating the collections at Kew and the British Museum, but none as to the facilities and assistance afforded by the officers of both establishments to botanists in their researches. The only objection we can see to the maintenance of two collections is the possibility of the officers being rivals in the acquisition of additions to their respective establishments; but a proper understanding between them would remove this danger.

Heer's Arctic Flora.—A third volume of this valuable work has been recently published from materials collected by the Swedish Polar expeditions under the direction of Professor Nordenskiöld. This volume admirably completes the work, by the superior character of its execution and by the interesting facts which it discloses in regard to the geological floras of the Arctic and Polar regions. It contains, 1st, a paper on the Carboniferous flora of the arctic zone (eleven pages and six plates); 2nd, the Cretaceous flora of the arctic zone (one hundred and forty pages with thirty-eight plates); 3rd, an appendix to the Miocene flora of Greenland (three pages and five plates); and 4th, a general division of the Miocene flora of the arctic zone (twenty-four pages).

The Red Colouring Matter of the Algæ.—A paper was read before the Linnæan Society (May 6), "On the Characteristic Colouring Matter of the Red Groups of Algæ," by Mr. H. C. Sorby, F.R.S. Mr. Sorby gave an account of some of the leading characters of the various remarkable blue, purple, and red substances, soluble in water, characteristic of red Algæ. The compound nature of the solutions obtained from the plants may be proved by the varying decomposing action of heat on the different colouring matters. He also showed that, though the Oscillatoria and Floridea both yield closely related colouring substances, their specific differences serve to separate those two groups of Algæ quite as much as their general structure. Connecting links do indeed occur, and the further study of this question will probably yield interesting results. Specimens illustrating these facts were exhibited.

Flora of the Island of Amsterdam.—The "Athenæum," writing on this subject, observes that it is a curious fact that the little island of Amsterdam, in the South Indian Ocean, is known to be covered with trees, whilst the island of St. Paul's, only fifty miles to the south, is destitute of even a shrub. Botanists have long been anxious to determine the character of the Amsterdam forest, but the difficulty of effecting a landing on the island has generally prevented the collection of specimens. In a late part of the "Journal of the Linnæan Society," Dr. Hooker announces that at length he has received the desired specimens, these having been collected by Commodore Goodenough, who states that they represent the only species of tree

growing on the island. Dr. Hooker identifies this with the *Phylica arborea* of Thouars, a tree which, strangely enough, is found in the remote island of Tristan d'Acunha. It is a curious problem for those who study insular floras to suggest how the same plant can have established itself on these two little specks of land, separated from each other by about five thousand miles of ocean.

The Physiology of Plants.—A good step is being taken in America towards the study of physiology of plant life. It seems that in a paper entitled "Observations on the Phenomena of Plant Life," by Mr. W. S. Clark, President of the State Agricultural College of Massachusetts, we have (says "The Academy," May 15) a record of a most interesting series of experiments instituted to determine: 1. The structure, composition, and arrangement of the winter buds of hardy trees and shrubs; 2. The percentage of water to be found in the branches and roots of trees during their annual period of repose, as well as when in active growth; 3. The phenomena and cause of the flow of the sap from wounds in trees when denuded of their foliage, as well as the flow from the stumps of woody and herbaceous plants when cut near the ground in summer; 4. The structure and functions of the bark of exogenous trees, with special reference to the circulation of the sap, the formation of wood, and the effects of girdling; 5. The expansive force of growing vegetable tissue. A number of the officers and students of the college co-operated with Mr. Clark in conducting the investigations, and all the details of the work appear to have been observed and recorded in a most conscientious manner. The results, generally, bear out the theories held by the most eminent physiologists; but the marvellous vital forces revealed are surprising, even after all we previously knew of the lifting powers of plants. Possibly some of our readers may have their doubts respecting the accuracy of the data, and the means employed to register the forces. The experiments undertaken to measure the expansive force of growing vegetable tissue illustrated this phenomenon in a most remarkable and indisputable manner. The subject chosen for this purpose was the squash or mammoth pumpkin, *Cucurbita maxima.* The experiments made on it are fully described in "The Academy" referred to.

Mr. Berkeley's Observations on Agaricus ascophorus. — The following remarks of this distinguished botanist are from the "Gardeners' Chronicle" (April 17, 1875):—"We have lately received, through Dr. M. C. Cooke, a specimen of *Agaricus ascoporus* (Peck), sent by that gentlemen from New York. The species clearly belongs to the subgenus *Flammula,* and we therefore felt greatly interested in examining the gills for the supposed asci. We readily discovered the bodies in question, but we could by no means satisfy ourselves that they were really asci containing speridia. The singular matter is that besides these bodies there are forked ascidia, which are far less numerous than the bodies in question. These, according to Mr. Broome's and our own observations, are shortly pedicellate, somewhat top-shaped bodies with a reticulate surface, the reticulations increasing in number with the process of growth. We do not at all consider them as asci, but as analogous to the hispid bodies which occur on the gills of some species of *Marasmius,* and possibly of the same nature with the echinulate bodies which are so obvious on the pileus of *Marasmius Hudsoni.* It is true

that asci have been observed on the gills of *Agaricus melleus*, but this was probably due to the presence of some species of Hypomyces; and the observation has not been confirmed. Indeed, late examinations of the spores of some *Coprinus* under germination seem to show that impregnation takes place at a very early period, and that the result is a sporiferous fungus; as in *Ascobolus* or *Peziza*, we have from the same process a sporidiferous fungus. The spores of *Agaricus ascophorus* were like those of allied *Flammulæ*, and were ·0004 in. in length. The dried gills did not show the spicules when moistened."

Remedies for the Vine Disease.—It appears, from a report supplied to the French Academy, that the most efficacious remedies for vines attacked with the phylloxera are alkaline sulphocarbonates, that of soda being the most effective. It is applied in solution, and destroys the insects without injuring the vine. Not being, as yet, an article of commerce, it has had to be specially prepared. It is expected to be an economical application when it comes into general use, and a large demand is created.

The late Mr. W. Wilson's Moss Herbarium has, according to the report of Mr. Carruthers, F.R.S., been acquired by the British Museum. The reporter says ("Journal of Botany," June):—"The most important acquisition is the moss herbarium of the late William Wilson, of Warrington, the remaining portion of which was purchased from his executors during the year. Mr. Wilson had devoted his life to the study of mosses, was the author of the standard work on 'British Mosses,' and of numerous memoirs on exotic species. His extensive herbarium contains the type specimens of those various works, and it abounds in original drawings prepared with singular accuracy, and with manuscript notes of great critical value. It consists of a collection of British mosses and Jungermannieæ, as well as a collection of foreign specimens of these two orders. The British herbarium is accompanied with an extensive correspondence with muscologists, and includes numerous authentic specimens from Dawson Turner, Th. Taylor, Sir William Hooker, and other authors of species. Mr. Wilson's herbarium of foreign mosses contains type specimens from the herbaria of Montagne, Bruch, Schimper, Angstrom, Mougeot, Zetterstedt, Hooker, Arnott, the Paris Museum, &c."

Return of the Botanist from Mr. Margary's Expedition.—The "Journal of Botany" (May, 1875) states that Dr. John Anderson, the naturalist to the recent expedition to South-Eastern China, which met with so much opposition from the natives, and resulted in the death of Mr. Margary, has returned to Calcutta, and is now on his way to England. He succeeded in escaping with his life, but lost all his property, including his collections and apparatus.

Paris Botanical Prizes.—The Paris Academy of Sciences has awarded the following prizes for botanical work: The Barbier Prize (in part) to M. I. Chatin, for studies of the *Valerianeæ;* the Desmazières (1872) to M. M. Cornu, for a monograph of the *Saproleguieæ;* and 1,000 francs to M. Bornet, for his labours among lichens; 1,000 francs to M. Lefranc, for his paper on *Atractylis gummifer;* the Desmazières (1873) to M. Girodot, on the *Lemaneaceæ* (Algæ); and 1,000 francs to MM. Van Tieghem and Lemonnier, on the *Mucorineæ;* the Bordin (1873) to M. J. Vesque, for the

anatomy and physiology of Dicotyledons; and the Gegner (4,000 francs) to good works on fossil botany, approved by M. Brougniart.

The Colouring Matters of Plants.—A most important paper on this subject is that by Herr N. Pringsheim, in the "Journal of Botany" for April (reproduced from the "Monatsbericht" of the Academy of Berlin). He says, towards the conclusion of his valuable paper: "It must now appear evident why I could not agree with Fremy, Filhol, or Kraus in their descriptions of the green and yellow chromules, and still less with Sorby respecting the several chromules which he alleges to have obtained from various plants, and which he regards as distinct and undecomposed substances pre-existing in the plants, and capable of definite analysis. It is certain that many of these chromules must have been deprived of their original spectrum characteristics by the treatment to which they were subjected. In the determination of the spectra, moreover, the influence of the solvents, that of concentration, and of the thickness of layers, seems to have been equally disregarded. It is clear that a single spectrum can give us no adequate information as to the absorption phenomena of any chromule, unless we are acquainted beforehand with its phases of absorption, and know to which phase of the bands it corresponds. Sorby has nowhere stated, with reference to his yellow chromules, to which he ascribes two separate bands in the blue, to what extent the various positions of the bands are influenced by the solvents, nor how they depend on the thickness of the layers; nor does he state, that with an increase of the chromule additional bands do not appear. I doubt not that the whole, perhaps, of his yellow chromules—one only excepted—would suddenly reveal also the chlorophyll bands of the first half, if my method were applied."

The Membrana Nuclei in the Seeds of Cycads.—A very capital paper was read on this subject before the Linnæan Society, by Professor Thiselton Dyer, which is thus abstracted in the "Journal of Botany" (April, 1875):—"Heinzel had described this as a cellular structure, the cells of which had thick walls penetrated by ramifying tubes. There was reason, however, for believing that the membrane only represented the wall of a single cell, and was in fact probably the greatly enlarged primary embryo-sac. What Heinzel had taken for cells seemed really to be solid. They were arranged all over the membrane, after the fashion of what carpet manufacturers call a 'moss pattern.' They were possibly the débris of the thickened walls of the cells of the nucleus which had been destroyed by the enlargement of the primary embryo-sac."

The Observation of Plants.—A conference consisting of delegates from the Agricultural, Botanic, Royal Dublin, Horticultural, and Meteorological Societies, has, at the request of the last-mentioned, drawn up some "instructions" for the observation of the appearance of certain plants, insects, and birds. In the preparation of these instructions the conference was greatly assisted by the Rev. T. A. Preston, of Marlborough College, who has worked for many years laboriously at such records. A list of seventy-one of the most widely-distributed and commonest plants is given, and those who cannot undertake to observe so many are requested to pay attention to fourteen of them printed in capitals. This is followed by some very necessary instructions, and a table of the average dates for ten years, as observed at

Marlborough, of the appearance of the various species. So far as appears, it is only the observation of the date of first flowering that is required; the advent of other phases of vegetable life is no doubt less capable of definite determination, but would seem to be desirable. Blank forms for the record of "Phenological Phenomena," as the appearances of animals and plants are awkwardly styled, can be obtained of the Secretary of the Meteorological Society, 30, Great George Street, S.W., to whom also the said forms are to be returned at the end of each month.

CHEMISTRY.

The Mode of determining Glycerin and Succinic Acid in Wine.—M. Maumene has published a recent paper, which has been abstracted by the "Chemical News" (April 23) from "Les Mondes." It seems that the author holds that the quantity of these bodies, as produced by the fermentation of glucose simultaneously with alcohol, will be proportionate to the latter, and that the exact knowledge of their amount may thus indicate the quantity of extraneous alcohol added to wine. He prepares hydrated oxide of lead by decomposing a soluble salt of that metal with potash, and, after washing it well, suspends it in water. To half a litre of wine, concentrated by evaporation to 335 c.c., he adds oxide of lead enough to cause every trace of colour to disappear. A grey precipitate is formed. Filter, wash the precipitate, and evaporate to dryness in the water-bath. Treat the evaporated residue with absolute alcohol, holding a little hydrated oxide of lead in suspension. Stir, leaving the mixture to stand for some hours, and filter. The liquid thus obtained is colourless. If submitted to a current of carbonic acid it grows turbid, but becomes clear again on filtration. It is dried at 110° C., and weighed as pure glycerin. To determine succinic acid, treat a litre of wine with albumen, or raw hide, in sufficient quantity to remove all the tannin. Mix with hydrated oxide of lead (after concentration) till the colour is entirely removed, and preserve the filtrate for the determination of glycerin. The precipitate is kept for a long time in contact with boiling water, containing about 10 per cent. of nitrate of ammonia. The clear liquid, obtained on fresh filtration, contains all the succinic acid in the state of succinate of lead, besides other salts of the same base. It is treated with sulphuric (sulphurous) acid, and filtered again, when we have a perfectly colourless liquid containing free succinic acid. After having heated to expel the excess of sulphuric (sulphurous ?) acid, the liquid is concentrated to about 100 c.c., and neutralised with ammonia. Heat sufficiently to expel any excess of ammonia, and add a few drops of ferric chloride, which has been previously kept for a long time in contact with sesquioxide of iron, so as to ensure the absence of free hydrochloric acid. Finally, collect the deposit of succinate of iron which forms, wash it well, ignite, and weigh the residual sesquioxide. This weight, × 1·978, gives the quantity of succinic acid existing in the quantity of wine analysed.

Hydrogen in the Metals.—It is stated by M. M. Troost and Hautefeuille

that ("Comptes Rendus," March 29) potassium, sodium, and palladium combine with hydrogen, whilst a considerable number of other metals merely dissolve this gas. Iron, nickel, cobalt, and manganese offer striking analogies in the manner in which they behave with hydrogen at different temperatures. The facility with which they absorb or give off hydrogen gas depends greatly on their physical condition. An ingot of pure nickel gave out, in a vacuum, at a red heat, one-sixth of its volume of hydrogen. Laminæ of nickel, obtained electrolytically, gave out forty times their volume. Pulverulent nickel gave out one hundred times its volume, and remained pyrophoric after the escape of the hydrogen. An ingot of cobalt gave out one-tenth of its volume, electrolytic laminæ of cobalt thirty-five times their volume, and pyrophoric cobalt powder one hundred times. It also remained pyrophoric after the loss of the hydrogen. Soft iron in ingots gives off one-sixth of its volume, and grey cast-iron more than the half. Electrolytic laminæ of iron gave off 200 volumes. In fine, it may be said that iron, nickel, and cobalt absorb directly hydrogen gas, but it cannot be said that combination ensues, just as has been already shown in the case of lithium and thallium.

Carbonic Acid in the Air.—In the recent balloon ascent in the "Zenith" by M. G. Tissandier, that gentleman examined the amount of carbonic acid present in the air. At the altitude of 800 to 890 metres, at the temperature of 0°, and the pressure of 760 m.m., the amount of carbonic acid in 10,000 parts was 2·40. At 1,000 metres the proportion was 3·00. These differences are within the limits of variation of experiments made on the surface of the earth.—*Comptes Rendus*, April 12.

Peculiar polarisable Substances normally found in Wine.—The "Chem. News" for April 12 gives a note on a paper by M. Béchamp recently read before the French Academy. It says that wine decolourised, suitably concentrated, and freed from tartar, yields a solution which, in some cases, turns the plane of polarisation to the left, in some to the right, and in others occasions no deviation. When it turns to the left it is because the quantity of non-crystalline sugar is more than sufficient to compensate for the effect of the dextro-gyratory matters. When it turns to the right, the quantity of lævulose is too small to compensate the action of the dextro-gyratory matters, or else it has been entirely destroyed. If there is no deviation, the dextro-gyratory matters are exactly compensated by the lævulose, or all the active matters have disappeared. Neither the sacchari-meter nor the cupro-potassic reagent are safe processes for the determination of the sugar in wines. Hence, fermentation alone appears trustworthy.

Detecting Lead in the Tin Lining of Vessels.—M. Fordos has given a new and rapid process for the above in a paper read before the French Academy (March 29, 1875). He says: "Place, with a tube plunged in pure nitric acid, a slight layer of acid upon any part of the tinning, selecting by preference the thickest parts. Both metals are attacked, forming stannic oxide and nitrate of lead. After a few minutes heat slightly to expel the last traces of acid, and allow to cool; then touch the pulverulent spot produced by the acid with a tube dipped in a solution of 5 parts of iodide of potassium in 100 of water. The iodide has no action upon the oxide of tin, but with the nitrate of lead it reacts, forming yellow iodide of lead, and showing the

presence of even a small quantity of this metal. The surface of the tinning must be carefully cleansed before applying the nitric acid, and the acid should not penetrate to the iron or copper which forms the body of the vessel, as the reaction might thus be complicated."

A non-arsenical Green Paint is a matter of some importance, but not easily obtained. It seems likely, however, that it has been produced by Signor A. Casali. This Italian chemist states ("Gazzet. Chim. Italiano," Anno IV., Fasc. 9): "That the existing chrome greens, such as Guignet's green (hydrated sesquioxide of chrome), called also emerald green, and Pannetier's green; green ultramarine (anhydrous chromic oxide), Leune and Castelhaz's green (hydrated chromic oxide), Arnaudon's green (chromic metaphosphate?), Matthieu Plessy's green (phosphate), leave little to be desired in point of beauty, and are free from injurious properties, but are too expensive to compete with the arsenical greens. He proposes in their stead to calcine strongly an intimate mixture of 1 part of bichromate of potash and 3 parts of baked gypsum, of the variety commonly known as scagliola. The result is a grass-green mass, which, on boiling with water, or mixing with dilute hydrochloric acid, leaves a fine powder of an intense and beautiful green, and possessing a very high colouring power.

The Detection of Common Alcohol in Wood-spirit has been recently carried out by M. Berthelot (see "Comptes Rendus," April 26, 1875). The process consists in mixing the suspected liquid with double its volume of concentrated sulphuric acid. In these conditions methylic alcohol yields gaseous methylic ether, entirely absorbable by water or concentrated sulphuric acid, whilst ordinary alcohol produces ethylen, a gas almost insoluble in water, and concentrated sulphuric acid, but which may be recognised and determined by causing it to be absorbed in bromine. On operating with the precautions customary in gaseous analysis, the presence of common alcohol may be detected in wood-spirit, even when the proportion does not exceed 1 or 2 per cent. Aceton and the normal impurities of wood-spirit may yield, under these circumstances, carbonic acid and carbonic oxide, but not ethylen.

The Detection of Amylic Alcohol in Spirits of Wine.—This process, which is just the reverse of that previously described, is given in an Italian chemical journal (see also the "Chemical News," May, 1875) by Dr. C. Betelli. It is as follows:—Dilute 5 c.c. of the suspected alcohol with 6 or 7 volumes of water. Add 15 or 20 drops of chloroform, shake strongly, and leave at rest. The deposit of chloroform is collected, and allowed to evaporate spontaneously, when the amylic alcohol is left as a residue, and may be recognised by its well-known odour, its reaction with sulphuric acid, &c.

The Gases evolved from Apples.—An examination of these has been made by Herr Bender, who has published the results in the "Berlin Chem. Ges" (viii. 112). The fruit, cut in pieces, was placed in water free from air contained in a flask furnished with a delivery-tube. On raising the temperature to 60°, the gas began to come off, and at 100° the evolution was rapid. Four moderately-sized apples afforded about 100 c.c. of gas. Upon eudiometric analysis this gas—great care having been taken to exclude the air—was proved to consist of 59·37 per cent. of nitrogen, and 40·20 per

cent. of carbonic acid, the remaining 0·43 per cent. being oxygen. In a subsequent experiment, 31·07 per cent. of the gas was carbonic acid and 68·93 per cent. nitrogen. The author believes that the carbonic acid comes from a fermentation within the fruit, the ferment being produced at the time of ripening.

Action of Light on Iodide and Bromide of Silver.—Mr. Carey Lee, who is one of our best authorities on this subject, has contributed an important article to "Silliman's American Journal" (April 1875). In this he has given the results of 160 experiments. The results, with such slight and altogether unimportant variations as necessarily arise from slight differences of preparation and differences in the character of the sun's light, were remarkably concordant, and may be summed up as follows:—

1. AgBrI and Ag are sensitive to all the visible rays of the spectrum.
2. AgI is more sensitive than AgBr to all the less refrangible rays and also to white light.
3. The sensitiveness of AgBr to the green rays was materially increased by the presence of free silver nitrate.
4. AgBr and AgI together are more sensitive to both the green and the red rays (and probably to all rays) than either AgI or AgBr separately.
5. There do not exist any rays with a special exciting or a special continuing power, but all the coloured rays are capable both of commencing and continuing the impression on silver iodide and bromide.

GEOLOGY AND PALÆONTOLOGY.

The Evolution of the Crocodilia and on Stagonolepis Robertsoni.—One of the most important papers that have for some years been read before the Geological Society was that of Professor Huxley on the above subject (April 28, 1875). After referring to his paper read before the Society in 1858, the author stated that he had since obtained, through the Rev. Dr. Gordon of Birnie, and Mr. Grant of Lossiemouth, further materials, which served at once to confirm the opinion then expressed by him, and to complete our knowledge of *Stagonolepis*. The remains hitherto procured consist of the dermal scutes, vertebræ of the cervical, thoracic, lumbar, sacral, and caudal regions, ribs, part of the skull and the teeth, the scapula, coracoid and interclavicle, the humerus, and probably the radius, the ilium, ischium, and pubis, the femur, and probably the tibia, and two metacarpal or metatarsal bones. The remains procured confirm the determinations given by the author in his former paper, except that the mandible with long curved teeth, therein supposititiously referred to *Stagonolepis*, proves not to belong to that animal. The crocodilia were divided by the author into three groups. The paper is of much interest.

Boring Mollusca in the Oolitic Rocks.—In the "Agricultural Student's Gazette" (April), a journal published at Cirencester, Professor J. Morri's has an excellent paper on the above subject, of which we can only give a part. The rocks examined were those of a quarry situated near the canal on the farm land of Mr. Sargeant, which has been long worked for road stone

and building stone, and, according to the Geological Survey, belongs to the Forest Marble division of the Great Oolite series, and exhibits the structure known as "false-bedding or oblique lamination;" and occasionally the flagstones in this and other neighbouring quarries show ripple-marks and tracks of marine animals.

A portion of the upper surface has been removed, and the following is a general account of the section seen in the quarry in *descending* order:—Rubbly limestone, about four feet; brown shaley clay, with thin calcareous shaley bands, slightly oolitic, full of oysters, *O. Sowerbyi*, of different sizes, more or less broken, and other fossils. At the level of this bed in one part of the quarry were the nodules, round or lenticular in shape, of a fine, compact, highly calcareous and ferruginous claystone, or indurated marl, of light brown colour, both the under, lateral, and upper surfaces of which have been perforated by some boring mollusc, as *Lithodomus* or *Gastrochæna*; the holes are pear-shaped, and are found all round the margin of the nodules, and are filled either with a yellowish-brown mud with some oolite grains, due to subsequent infiltration, or with crystallised calcite; in some cases the shells of the mollusc have been preserved. Besides the perforations, the surfaces of many of the nodules are covered with attached valves of oysters and a carinated *Serpula*, the interspaces, as well as the valves of the oysters, being incrusted with a delicate species belonging to the *Polyzoa*, probably a *Berenicea* or *Diastopora*; the thickness of this bed is about three feet. The nodules are coated with similar species of *Polyzoa* and of *Serpula* to those which incrust the separate plates and joints of the *Apiocrinus rotundus*, which occur in the Bradford-clay at Bradford, Wiltshire. Coarse shelly limestones, more or less irregular and false-bedded, with partings of clay full of fossils; among the most common are *Terebratula digona*, *Lima cardiiformis*, *Pecten vagans*, *Modiola imbricata*, *Ostrea Marshii*, *O. Sowerbyi*, *Trigonia*, *Corbula*, *Nucula*, *Arca*, *Serpula*, spines and plates of *Echini* (*Acrosalenia* and *Cidaris*), Corals (*Cladophyllia Babeana*), *Rhynchonella media*, *Cerithium*, *Cylindrites*, *Nucula*, and fragments of wood.

Sir Charles Lyell's Gift to the Geological Society.—At the meeting of the Geological Society on March 24 (just when our last number was "at press"), the President announced that the late Sir Charles Lyell had bequeathed to the Society the sum of 2,000*l.* for the purposes stated in the following extract from his will:—"I give to the Geological Society of London the die executed by Mr. Leonard Wyon of a medal to be cast in bronze and to be given annually and called the Lyell Medal, and to be regarded as a mark of honorary distinction and as an expression on the part of the governing body of the society that the medallist (who may be of any country or either sex) has deserved well of the science. I further give to the said society the sum of two thousand pounds (free of legacy duty) to be paid to the president and treasurer for the time being, whose receipt shall be a good discharge to my executors; and I direct the said sum to be invested in the name of the said society, or of the trustees thereof, in such securities as the council shall from time to time think proper, and that the annual interest arising therefrom shall be appropriated and applied in the following manner: not less than one-third of the annual interest to accompany the medal, the remaining interest to be given in one or more portions, at the discretion of the council, for the

encouragement of geology or of any of the allied sciences by which they shall consider geology to have been most materially advanced, either for travelling expenses or for a memoir or paper published or in progress, and without reference to the sex or nationality of the author or the language in which any such memoir or paper may be written. And I declare that the council of the said society shall be the sole judges of the merits of the memoirs or papers for which they may vote the medal and fund from time to time. And I direct that the legacy hereinbefore given to the said society shall be paid out of such part of my personal estate as may be legally applicable to the payment of such bequests."

A Labyrinthodont from the Coal-measures.—Mr. J. M. Wilson read a paper on this subject before the Geological Society, April 14, 1875. The fossil referred to in this paper was from the Leinster Coal-measures, and was regarded as probably belonging to the genus *Keraterpeton* of Professor Huxley, although the outer posterior angles of the skull do not appear to have been prolonged into cornua.

Probable English Coal-fields.—Mr. C. Ketley, writing on this subject in the "Geological Magazine" for May, describes at some length the recent efforts which have been made at Sandwell. He says that, stimulated by the Sandwell success, other companies are forming to search for coal under the red rocks of large estates situate still further away from the "eastern boundary" of the old coal-field than Sandwell. Is it not probable that still higher coal-measures may be recognised? Is it not possible that the *Spirorbis Limestone* may yet be found over all, to prove the relation between the South Staffordshire and the Warwickshire coal-fields on the one hand, and the Wyre Forest coal-field on the other?

A New Geological Map of London.—We quite agree with the opinion expressed by our contemporary the "Geological Magazine" (May, 1875) that the publication by the Geological Survey of a Map with London as a centre will be hailed with satisfaction by those interested in the geology of the metropolis, and of the country within easy distance around it. Formerly one had to procure four distinct sheets of the Geological Survey Map of England, in order to obtain the whole of London geologically coloured, and then one obtained actually more than was necessary for the illustration of London geology or convenient as a diagram for the wall of the library. The present map embraces an area bordered on the North by Blackmore, Epping, Waltham Abbey, Potter's Bar, Watford, and Chesham Bois; on the West by Amersham, Windsor, Chertsey, and Cobham; on the South by Epsom, Croydon, Farnborough, and Shoreham; and on the East by Gravesend, Grays Thurrock, Brentwood, and Frierning. The map is published both with and without drifts; but it need hardly be said that for most practical and scientific purposes the map showing drifts is alone desirable, for no geological map on a scale of one inch to a mile can be considered complete if the superficial deposits be omitted. Their influence on the scenery of the district is trifling, for the main features were sketched out before the drift deposits were laid down: they rest indifferently upon the Tertiary strata and chalk, and yet many of them, and particularly the glacial deposits, have suffered much denudation.

The Origin of the Chesil Bank.—Professor Prestwich, F.R.S., has written

an interesting paper on this important question, which was originally read before the Institution of Civil Engineers. He considered that the action of the "Race" off Portland, and of the tidal waves during storms, combined to drive the shingle of the old beach at the Bill, and of that portion of it which must be spread on the sea-bed westward of Portland, on to the south end of the Chesil Bank, whence the shingle was driven northward to Abbotsbury and Burton by the action of the wind-waves, having their maximum force from the S.S.W., a direction which he showed to be the mean of the prevalent winds. Here, these wind-waves became parallel with the coast, and the westward movement ceased about Bridport, beyond which point the shingle travelled in the opposite direction, viz. from west to east, or from the coast of Devon to that of Dorset; the quartzite pebbles from the conglomerate beds of Budleigh Salterton, which travelled from that part of the coast eastward to and beyond Sidmouth, gradually diminishing in numbers as they approached Lyme, very few, if any, reaching Bridport. This conclusion was in accordance with the facts:—1. That the pebbles of the Devonshire and Dorset strata, which formed the shingle of the "raised beach," constituted also the bulk of the Chesil Bank. 2. That there were also, in that bank, pebbles of the rocks and flint of Portland itself. 3. That the largest pebbles occurred at the Portland end of the bank, the pebbles decreasing gradually in size to Abbotsbury. The large dimensions of the bank he attributed to the great accumulative and small lateral action of the waves.

MEDICAL SCIENCE.

Healing Ulcers by Transplantation of Skin.—The "Lancet" of May 22 states that M. Thiersch, having a patient whose leg had to be amputated in consequence of a large and incurable ulcer, thought it a good opportunity to examine the changes that take place when portions of skin are implanted on granulating surfaces. For three weeks previously he accordingly transplanted portions of skin day by day, the last pieces being applied eighteen hours before the amputation. The chief results arrived at were:—1. That adhesion occurs without the intervention of any intermediate cementing substance. The adherent parts are in immediate application, or at most are only separated by a couple of blood-corpuscles. 2. The adhesion, when complete, takes place by means of the inosculation of vessels, which may be observed even eighteen hours after the act of transplantation of the new skin. A connection is at this period seen to occur by intercellular passages extending between the sharply contoured vessels of the skin on the one hand and those of the granulations on the other, and these intercellular passages become proper vessels in the course of a few days. 3. At the same time the vessels of the skin beneath the transplanted portion undergo secondary changes; they become wide, irregularly dilated, with prominence on their walls, and in fact assume the characters of embryonal blood-vessels. 4. True new formation of vessels may perhaps take place when the primary inosculation fails. In such cases the epidermis and the pipillary bodies fall off after a little while, and the transplantation is

believed to have failed; but this is not so, since the subcutaneous connective tissue with the remains of the sweat-glands remain adherent. After the lapse of some time new-formed epidermis appears where the transplantation was made, which may perhaps be due to the germination of the remains of the sweat-glands. Thiersch finally recommends a modification of Reverdin's plan, namely, that the surface of the wound to which the skin is about to be transplanted should have any granulations that may be found upon it shaved off, and the new skin applied in the course of a few hours.

The Glands in the Placenta.—Professor Turner, who has been lecturing on the Placenta at the College of Surgeons on June 14, 15, and 16, described very fully the glands, which are tubular, more or less oblique in direction, and more or less branched. In the mare, pig, dog, and hedgehog they are closely arranged, whilst in the sloth, macacus, and chimpanzee they are very sparsely scattered. The glands are lined with a continuation of the epithelium covering the general surface of the mucous membrane. Leydig first demonstrated that they were columnar and ciliate in the pig, but this has since been shown to be the case in the cow, sheep, mouse, and bat. In regard to the course of the glands, Sharpey, from observations made on the bitch, thought there were shorter unbranched and longer branched ones, and this was supported by Bischoff, who concluded that the shorter ones secreted mucus, and the larger ones a special fluid. Professor Turner's own observations, made with higher microscopic powers than were used either by Sharpey or by Bischoff, is of opinion that there is no difference between them, the shorter ones being artificially produced by the section, in consequence of the longer ones not running straight, but at an angle. The drawing of the glands usually contained in text-books, taken from Weber, is conventional, and Professor Turner generally agrees with the account given by Dr. J. Williams in a recent paper.

The Duality of the Brain.—At a recent meeting of the Psychological Society (June 9) Mr. Serjeant Cox read a paper on the "The Duality of the Mind." He said that the fact of the duplicity of the brain, first asserted by Galt, and afterwards by Dr. A. Wigan and Sir Henry Holland, was now confirmed by Brown-Séquard, all of whom deduced from this brain-structure that the mental faculties are duplex—that we have, in fact, two minds. This explained a multitude of mental phenomena otherwise inexplicable, especially Dr. Carpenter's "Unconscious Cerebration;" and, if true was of incalculable importance to psychology. Many instances were narrated of total destruction of one hemisphere of the brain attended by only partial loss of mental power. An animated discussion followed, by Sir J. H. Maxwell, Rev. W. Moses, Major Owen, Mr. G. Harris, Mr. Coffin, and others, but not so much was said about this important matter as Brown-Séquard has recently stated.

Pistol-shot Wound; Ball passing beneath Brain.—The "New York Medical Journal" for May states that recently, at the Bellevue Hospital, an interesting case occurred of the above description. The patient, an Italian, is supposed to have attempted to commit suicide. The ball entered the side of the head, posterior to the orbit, and the only symptoms of injury were complete blindness of the left eye, with partial blindness of right.

There was also ptosis of the left lid. When examined by the ophthalmoscope, hæmorrhagic spots were found on the optic discs of both eyes, but most extensive on the left. The ball was lodged in the head still. The inference was that the course of the ball was below the brain, but sufficiently near to it to injure the orbital nerves. The pupils of both eyes were dilated, and did not respond to light.

Experiments on the Brain of Monkeys. — This is the title of a most valuable paper by Dr. D. Ferrier, of King's College. It is impossible to abstract it, but we commend it to our readers' notice. It was read before the Royal Society April 29.

The Sounds of the Heart.—Curiously enough, this point is still a debateable one, notwithstanding the immense importance of its being settled. Dr. G. Paton has a paper on the subject in the "New York Medical Journal" (May). In conclusion he says: "The following plan will more fully illustrate the manner in which the sounds of the heart are produced, premising that the statements made in reference to one side of the heart are equally applicable to the other.

"First sound, produced by ventricular contraction and aortic reaction.

"Second sound, produced by auricular contraction as the ventricle dilates.

"The first sound of the heart is produced at the origin of the aorta, but heard most distinctly towards the apex of the ventricle, where it approaches the walls of the thorax during the systole.

"The second sound is best heard towards the base of the sternum, over the right auriculo-ventricular foramen, as the auricles contract and pour the blood into their respective ventricles. It appears to be seated lower than the first sound of the heart."

Invalids sent by Railway in Twine Hammocks.—The "Lancet" (May 29) says: "When the Ashantee campaign was going on we called attention to a simple and very portable form of hammock, which was capable of being turned to many accounts in the field. On the 20th inst. a girl, who had lately been under treatment in the Westminster Hospital for a severe burn, was conveyed by railway in one of Seydel's twine hammocks from Victoria station to Margate. The hammock was slung in a parcel van, its points of suspension being nine feet apart; and the patient was placed in it with her feet towards the engine, and was very safely and comfortably transported to her journey's end. The chaplain and one of the sisters accompanied the patient, who was in charge of Mr. Richard Davy; and they all concur in praising the hammock as a pleasant and easy means of transport, very well adapted for invalids undertaking a journey by rail."

METALLURGY, MINERALOGY, AND MINING.

Crude Copper from Washiu.—The third annual report of the Director of the Imperial mint in Japan is an interesting document recently published. It is instructive from the light it throws upon the progress of chemistry and metallurgy in Japan. The chemists, engineers, assayers, engravers, &c., appear still to be all Englishmen. From the special memorandum of the

chemist, Mr. Gowland, we gather some interesting facts as to Japanese copper. The following analysis is given to show the composition of an average crude copper from Washiu:—

Copper	98·940
Lead	trace
Sulphur	0·947
Iron	0·101
Silver	trace
Arsenic	trace
Antimony	absent
	99·988

The Platiniferous Rocks of the Urals.—At a recent meeting of the French Academy of Sciences, M. Daubrée described the rocks of the Ural affording platinum. They have a base of chrysolite. The masses come from the conglomerates near Nischne Tagilsk, where platinum is obtained. Besides chrysolite, serpentine and chromic iron are intimately associated with the platinum. The facts seem to prove that the original platinum-bearing rock was a chrysolite rock more or less transformed into serpentine, and was accompanied with diallage, which is common in the specimens. The presence of chromic iron is also to be noted; for it appears to bear evidence as to the changes through which the gangue rock of the platinum had passed.

Effects of Cold on Iron.—At a meeting of the Academy of Natural Sciences of Philadelphia, Mr. Willard referred to two instances of the brittleness of iron under the prevailing low temperatures which he noticed the day before. In breaking up an old locomotive, the cutting off of the rivet heads, which usually requires heavy sledging, was effected by a single blow, as if they were made of cast iron. In the forging of a long steamboat shaft of the best hammered iron which hung balanced in a crane, the hammering of the heated end caused vibration in the overhung end—harmless in ordinary temperatures, but at 10° F. sufficient to cause the beam to break sharp near the point of support. The published tests of iron and steel show no loss of tensile strength at low temperatures under a gradual stress, but all experience shows great loss of *body*, or ability to resist a blow.

MICROSCOPY.

The Way in which Echinoderms are developed.—The following are stated by the "Monthly Microscopical Journal" (June 1875) to be conclusions drawn up by Mr. A. S. Packard.—"Echinoderms as a rule, are reproduced alone by eggs and sperm-cells. After fertilisation of the egg they pass through:—1. Morula stage. 2. Gastrula stage. 3. A larval, temporary stage (Pluteus, Brachiolaria, Auricularia). 4. The Echinoderm grows from a water tube of the larva, finally absorbing the latter, whose form is often materially changed during the process. It thus undergoes a true metamorphosis, in a degree comparable with that of some insects."

Angular Aperture; its Uses.—"The Academy" (May 8) says that this question, which is of great interest to microscopists, has just been brought before the Royal Microscopical Society by Mr. Slack, who contends that the extreme angles of aperture usually given to the higher objectives are bad substitutes for better correction of spherical aberration. In proof of this opinion, he showed that a glass by Zeiss of Jena, $\frac{1}{6}$, with an angle of only 68°, would display the transverse ribs of *Surirella gemma* divided into beads, when the object was illuminated by Mr. Wenham's dark-ground reflex apparatus. C and D eye-pieces were employed for this purpose, and the beads were quite distinct, though it was not pretended that they were as well shown as they could be with a higher power and larger angle. Zeiss's half-inch, the C of his catalogue, with 48° aperture, suffices to show the cross-beading of *Plerosigma hippocampus* with B and C eye-pieces and an achromatic condenser. A paper of Professor Abbe was quoted, alleging reasons why no dry objectives should have apertures of more than 105° to 110°, and why it was well to restrict immersion objectives to little more than 100°, so that $\frac{1}{25}$ could work well through covering glass a fifth of a millimètre in thickness. Objectives by Zeiss upon Professor Abbe's plan were found to unite in a remarkable degree the qualities of penetration and resolution.

Action of Cobra-poison on Vegetable Protoplasm.—The following very interesting experiments were made by Mr. Charles Darwin, and were published in a paper read before the Royal Society by Drs. Brunton and Fayer. Mr. Darwin says: "You will perhaps like to hear how it acted on *Drosera.* I made a solution of $\frac{1}{4}$ gr. to ℨij of water. A minute drop on a small pin's head acted powerfully on several glands, more powerfully than the fresh poison from an adder's fang. I also immersed three leaves in 90 minims of the solution; the tentacles soon became inflated and the glands quite white, as if they had been placed in boiling water. I felt sure that the leaves were killed; but after eight hours' immersion they were placed in water, and after about forty-eight hours re-expanded, showing that they were by no means killed. The most surprising circumstance is, that, after an immersion of forty-eight hours, the protoplasm in the cells was in unusually active movement. Now, can you inform me whether this poison, if diluted, arrests the movement of vibratile cilia? I dissolved $\frac{1}{2}$ gr. [of cobra-poison] in ℨj of water, so that I was able to immerse two leaves. It acted as before, but more energetically; and I observed more clearly, this time, that the solution makes the secretion round the glands cloudy, which I have never before observed. But here comes the remarkable point; after an immersion of forty-eight hours, the protoplasm within the cells incessantly changes form, and I never saw it on any other occasion so active. Hence I cannot doubt that this poison is a stimulant to the protoplasm; and I shall be very curious to find out in your papers whether you have tried its action on the cilia and on the colourless corpuscles of the blood. If the poison does arrest their movement, it will show that there is a profound difference between the protoplasm of animals and of this plant. Therefore if you try any further experiments I hope that you will be so kind as to inform me of the results. I may add that I tried at first 1 gr. to the ℥j, as that is my standard strength for all substances. It is certainly very remarkable that the poison should act so differently on the cilia and on the protoplasm of *Drosera.* After

the forty-eight hours' immersion, I placed the two leaves in water and they partially re-expanded. I thought that the whitened glands were perhaps killed; but those of one leaf which I tried with carbonate of ammonia absorbed it, and the protoplasm was affected in the usual manner. I am very much surprised at the action of the poison on the viscid secretion from the glands, which it coagulates into threads and bits of membrane, with much granular matter. Have you observed whether the poison affects in any marked manner mucus or other such secretions?"

Microscopical Papers.—The following papers have been published in the "Monthly Microscopical Journal" for April, May, and June last:—

Some Remarks on Bucephalus Polymorphus, by Mr. John Badcock, F.R.M.S.; together with Translations from Papers of Von Baer, Lacaze-Duthiers, and Alf. Giard, on B. Polymorphus and Haimeanus, by Henry J. Slack, F.G.S., Sec. R.M.S.—On the Principle of testing Object-glasses by Miniatures of Illuminated Objects examined under the Microscope, especially of Sun-lit Mercurial Globules; and on the Development of Eidola or False Images. By Dr. Royston-Pigott, M.A., F.R.S., F.R.A.S., F.C.P.S., formerly Fellow of St. Peter's College, Cambridge.—On a Method of obtaining Oblique Vision of Surface Structure, under the Highest Powers of the Microscope. By F. H. Wenham.—On the Connection between Fluorescence and Absorption. By H. C. Sorby, F.R.S., &c., President R.M.S.—Further Researches into the Life History of the Monads. By W. H. Dallinger, F.R.M.S., and J. Drysdale, M.D., F.R.M.S.—On New and Improved Microscope Spectrum Apparatus, and on its Application to various Branches of Research. By H. C. Sorby, F.R.S., &c., Pres. R.M.S.—Some Remarks upon Sphæria (Gibbera) morbosa (Schw.). By Charles B. Plowright.—The Amœban, Actinophryan, and Difflugian Rhizopods. By G. C. Wallich, M.D., F.L.S., &c.—Note on the Diagnosis of Blood Stains. By Jos. G. Richardson, M.D., Microscopist to the Pennsylvania Hospital, Philadelphia, U.S.A.—On Bog Mosses. By R. Braithwaite, M.D., F.L.S.—On Angle of Aperture in Relation to Surface Markings and Accurate Vision. By Henry James Slack, F.G.S., Sec. R.M.S.—Measurements of the Möller Probe-Platte. By J. Edwards Smith, Esq., Ashtabula, O., U.S.A.

PHYSICS.

An American View of Young.—A paper appears in "Silliman's American Journal" (April 1875), which gives Mr. A. M. Mayer's view of Young's abilities. Mr. Mayer, who is a distinguished physicist, in reviewing Young's theory of light, says: "That he should have delayed to bring to the test of experiment a plausible hypothesis, when other men would at once have appealed to the instruments in their laboratories, is explained by the fact that Young 'at no period of his life was fond of repeating experiments or even of originating new ones. He considered that, however necessary to the advancement of science, they demanded a great sacrifice of time; and that, when a fact was once established, that time was better employed in

considering the purposes to which it might be applied or the principles which it might tend to elucidate.' Indeed, this peculiarity receives abundant confirmation from his own words; thus, in the Bakerian Lecture, he says: 'Nor is it absolutely necessary in this instance (in speaking of the proofs to be adduced in support of the undulatory theory of light) to produce a single new experiment; for of experiments there is already an ample store;' and in a letter written in November 1827, to his sister-in-law, Mrs. Earle, on the respective honours given by Herschel, in his 'Optics,' to Young and Fresnel, he says: 'And acute suggestion was then, and indeed always, more in the line of my ambition than experimental illustration.' Young carried his opinion of the secondary importance of experiment so far as even to object to the increase of the fund left by Wollaston to the Royal Society to aid experimental inquiries, in these words: 'For my part, it is my pride and pleasure, as far as I am able, to supersede the necessity of experiments, and more especially of expensive ones.'" *

Intermittent Ebullition.—Dr. .I. L. Phipson, writing in the "Chemical News" (April 23), states "that water strongly acidified with hydrochloric acid, and containing a small quantity of benzol, was found to enter into violent ebullition every 60 seconds; after a while the boiling ceased completely, and then recommenced suddenly every 30 seconds for some time. The flask still being kept over the spirit lamp, the periods between quiescence and violent ebullition dropped to 20, 10, and finally to 8 seconds, at which interval the phenomenon continued for some considerable time. The temperature of the vapour in the flask was 101° C., in the liquid 103·5° C., during the whole time of the experiment. When methyl alcohol was added to the above mixture of water, hydrochloric acid, and benzol, and the flask placed over a spirit lamp, no ebullition at all occurred for a very long space of time, and then it took place very suddenly, and continued."

A New Form of Auxiliary Air-pump.—At the meeting of the Physical Society on April 24, Mr. J. Barrett exhibited an "auxiliary air-pump" which is a modification of Poggendorff's arrangement for obtaining a Torricellian vacuum, and is also allied in principle to the exhauster used by Geissler in the preparation of vacuum tubes. The following is a description of the instrument, but it is difficult to explain its action without the aid of a diagram:—A cylindrical glass vessel, containing about 60 lbs. of mercury, is connected by a glass tube, $\frac{3}{4}$ of an inch in diameter, with another similar vessel, which is placed about 18 inches above it. The upper vessel is divided near the top into two parts, which are connected by a short neck. The tube communicating with the receiver passes into this vessel, and is alternately opened and closed below the neck, as the mercury rises and falls, by a floating valve. This upper vessel is in permanent connection with a glass vessel at the back of the instrument, which is rendered vacuous in the ordinary way, and the mercury keeps its place in the upper vessel until the lower one is rendered vacuous by the air-pump. A platinum valve in the back of the upper vessel retains a certain quantity of mercury, when the bulk of the mercury (with which the whole vessel is filled at the commencement of operations) falls by its weight into the lower vessel, which, as has been stated, is rendered vacuous by the air-pump. The interval between the two volumes of mercury is a Torricellian vacuum, into which the residual air

flows through the floating valve, which again closes as the mercury rises in the upper vessel and forces through the platinum valve, and upper column of mercury, the air which has entered from the receiver. It is possible to obtain a very good vacuum in a larger receiver by the aid of this instrument.

How Pressure influences Combustion.—This has been very well shown by M. Cailletet, an abstract of whose recent paper on the subject appears in "Silliman's American Journal," May 1875. M. Cailletet has studied the effect of a pressure of 30 to 35 atmospheres on the luminous, calorific, and chemical rays, emitted by a burning body. The air was compressed by pumps in which the pistons were fixed and the cylinders moveable, a layer of water or glycerine at the same time cooling the gases so as to protect the packing from the heat and preventing leakage. The reservoir consisted of a hollow cylinder with four apertures; the first admitted the gas, the second allowed it to escape, the third admitted the manometer-tube, and the fourth was closed by a thick glass plate to allow of observation of the interior. The latter had a diameter of 10 cms. and a capacity of about 4 litres. Placing a lamp in this space, the brightness increased with the pressure of the air. The base of the flame, which under the ordinary pressure is blue and transparent, became white and very bright; but soon the appearance changed and thick clouds of smoke circulated through the apparatus and escaped by the stopcock closing the outlet. The flame seen through this smoke is reddish and the wick is found to be charred and much soot deposited, doubtless owing to the dissociation of the gases containing carbon.

Spectrum-photographs.—"The Academy" of April 24, states that in the last number of "Poggendorff" H. W. Vogel describes a simple apparatus for photographing the spectrum of the sun, or other spectra. He removes the lens from an ordinary photographic camera, and replaces it by a pocket spectroscope, fitted into the aperture by means of a blackened cork. The sun's rays are allowed to fall on the apparatus parallel to the axis of the spectroscope. The lines, though not very sharp, are sufficiently so for many purposes, *e.g.*, for the comparison of absorption spectra.

Defects of the Human Eye as regards Achromatism.—A paper has been read on this subject before the Physical Society of London (April 10, 1875), by Professor H. M'Leod. He said that the eye has been thought to be achromatic because it is so practically; but it is easy to offer abundant evidence of the defects of the organ in this respect. For instance, to short-sighted persons the moon appears to have a blue fringe. In using the spectroscope the red and blue ends of the spectrum cannot be seen with equal distinctness without adjusting the focussing glass. A black patch of paper on a blue ground appears to have a fringed edge if viewed from even a short distance; while a black patch on a red ground, when observed under similar conditions, has a perfectly distinct margin. Professor M'Leod then explained that the overlapping of images in the eye produces the mental impression that there is no want of achromatism. It is interesting to note that Wollaston considered that the coloured bands of the spectrum were really divided by the black (Fraunhofer) lines; and his statement that the red end of the spectrum does not appear to have a boundary line "because the eye is not competent to converge the red rays properly," shows that he

had very nearly, if not quite, discovered the achromatic defects of the eye. Dr. Young ascribes to Wollaston the merit of having observed that when a luminous point is viewed through a prism, the blue end appears to be wider than the red, the eye being incapable of recognising that the spectrum has the same width throughout its entire length. An experiment was exhibited to show the relative distinctness of a dark line on grounds of various colours. A string or wire was so arranged that its shadow traversed the entire length of the spectrum, which was thrown on a screen by an electric lamp. When viewed from a short distance the edges of the shadow appeared to be sharp at the red end, but gradually became less distinct, until at the blue end nothing but a blurred line remained.

The Velocity of Light.—Professor Cornu gave a recent lecture on this subject before the Royal Institution (May 7, 1875). In this he described his recent experiments on the determination of the velocity of light. He gave an account of the method of Foucault, and exhibited the complete apparatus, including the arrangement of mirrors for multiplying the distance through which the luminous ray passed between the two reflections from the revolving mirror. He described the toothed wheel of Fizeau, and the improvements which he had himself made in his own determinations by this method. He found that it was impossible to give a uniform motion to the toothed wheel, and therefore adopted an electrical registering apparatus to mark the increase of its velocity, an electric signal enabling the observer to point out the instant at which the right velocity is obtained. Another very important improvement is the substitution of a pair of observations of the return rays for the single observation of a total extinction. Prof. Cornu's most recent determination was made in the summer of 1874, the two stations being the Paris Observatory and the Tower of Monthéry, 14½ miles apart. A mean of 508 experiments gave 300,400 kilometres, or 186,660 miles per second.

The Aurora's Spectrum.—Mr. J. R. Capron has ("Philosophical Magazine," April, 1875) described the results of comparison of auroral spectra with the spectra of hydrogen, carbon, oxygen, air, phosphoretted hydrogen, and iron. Mr. Capron considers that the conclusion of Angström, that the "moisture in the region of the aurora must be regarded as nil" cannot be maintained. He sums up the present state of our knowledge of the aurora question as follows:—"The yellow-green line, and possibly also the red, are due to phosphorescence or fluorescence; the fainter lines are partly due to the air spectrum, and the remaining bands or lines may be due to phosphorus and iron, the close coincidences in this latter spectrum with the lines being very striking."

Physical Science Popularised.—The "Chemical News" (May 28, 1875), quoting from "Iron," very justly calls attention to a scandalous ignorance of science lately exhibited. It says: "It is one of the most hopeful signs of the times that everybody is now supposed to know a little science. Some of us know very little. Others know a good deal, but the arrangement is somewhat confused. We scarcely know to which class the compiler of the 'Yorkshire Exhibition Guide' belongs. Whatever amount of scientific knowledge he possesses, he certainly has the art of 'combining his information,' and presenting it to his readers in a fresh, cheerful, and in-

teresting manner. He says: 'A medal and plate formed of the new metal, palladium, will be interesting to scientific men. The discovery of this metal by Professor Graham a few years ago finally settled the long-disputed point as to whether or not the gas hydrogen was a metal. He proved that palladium was simply hydrogen condensed. This may be easily exemplified by placing a piece of the metal under the receiver of an air-pump and exhausting the air. The solid metal at once flies off as a gas, and on readmitting the air it shrinks again into its former size. The little medal shown contains 100 times its volume of the gas.' We will only add, in transferring this gem to our columns, that we hope it is not a fair sample of the teaching at the Leeds Mechanics' Institute—the worthy object for whose benefit the Yorkshire Exhibition is being held."

A Revolving Polariscope was exhibited by Mr. Spottiswoode, F.R.S., at the Physical Society, on the evening of May 22, 1875. The following is an account of the apparatus:—A luminous beam passes from a small circular hole in a diaphragm through a polariscope, the analyser of which is a double-image prism, the size of the hole being so arranged that the two luminous discs shall be clear of each other. If the prism be made to revolve rapidly, one of the discs revolves round the other, and is merged into a ring of light which is interrupted at opposite sides by a dark shaded band, the position of which depends upon that of the original plane of polarisation. The discs may be coloured by inserting a selenite plate, and the rapid revolution of the analyser then gives alternating segments of complementary colours; or, if a quartz plate be used, the rotating disc passes successively, twice in a revolution, through all the colours of the spectrum, and when the revolution is rapid merges into a prismatic ring. The effect of the interposition of a $\frac{1}{4}$-undulation plate, which converts plane into circularly polarised light, was then shown, and Mr. Spottiswoode also interposed a concave plate of quartz and exhibited the effect of rotation on the characteristic rings of quartz.

The Effect of having Glass Rods Cleaned.—Mr. Tomlinson, F.R.S., whose views on this subject are generally known to our readers, has recently ("Phil. Mag.," April, 1875), been opposing the opinions of M. Gernez. Mr. Tomlinson maintains that the inactivity of a glass rod or other solid body introduced into a gaseous solution depends on its being chemically clean. A cage of fine wire gauze was submerged in soda-water, but there was no escape of gas so long as it was chemically clean. When taken out, rolled between the slightly greased hands, and again lowered into the soda-water, the gas escaped from its side in bubbles with an audible noise. Supposing a liquid, at or near its boiling point, to be constituted like soda-water, Mr. Tomlinson refuses to admit that a solid, such as a glass rod, introduced into a boiling liquid (water for example), becomes covered with bubbles of steam by virtue of the air carried down by the rod. If the rod be unclean (that is, contaminated with a greasy film), the steam-bubbles cover it precisely after the manner of gas-bubbles, because there is adhesion between the steam-bubbles and the film, and not between the water and the film, and hence there is a separation. A chemically clean glass rod has no such action, not because the act of cleaning it deprives it of its adhering air, but because there is perfect adhesion between a vaporous supersaturated solution and a chemically clean surface.

Toughening Glass.—The important discovery of M. de la Bastie is explained very fully in a paper by Mr. P. F. Nursey in our present number. In the course of Mr. Nursey's experiments before the Society of Arts, some glass dessert-plates were dropped from a height of between four and five feet to the ground without fracture, one of them rebounding over a table. Subsequently one of the audience dropped a plate from a height of four feet on to an iron grating, and it rebounded to the height of a foot without injury. Grease-catchers, to put on candles, were thrown with some force from the same height with similar result, except when four were thrown together, and then one of them broke into innumerable fragments, without the sharp cutting edges which are so characteristic of the fracture of glass not so toughened. A piece of plate glass about six inches square and a quarter-inch thick was next put into a frame of wood, so as to raise the under surface of the glass half an inch from the floor. A brass 4-oz. weight was then dropped several times from a height of ten feet fairly on to the centre of the piece of glass with perfect impunity. Next an 8-oz. weight was tried with the same result. Then a piece of $\frac{1}{8}$-inch plate was substituted, and the lecturer, a man approaching 12 stone in weight, put his heel in the centre and spun round on it. Next the 8-oz. weight was dropped on it, and, as in the case of the thicker piece, without the slightest damage. A piece of the same quarter-inch plate glass, which had not been toughened, was broken with the usual star fracture by dropping the 4-oz. weight from a height of two feet. At last, as it seemed impossible to break the plates of glass in any other way, a hammer was brought, and a smart blow being given to one of the quarter-inch thick plates, it shivered into a great number of very small pieces, and with the peculiarity of the edges of the pieces being rounded, as if partially fused after fracture.

Mr. Crookes' Discovery: the Mechanical Power of Light.—On this very important subject the discoverer has already contributed two papers (the second on April 27) to the Royal Society. In these, as in his especially beautiful and elaborate experiments, conducted at the Royal Society's soireé, Mr. Crookes has, we think, proved that light alone—all heat being absorbed—is sufficient to produce mechanical force. Professor O. Reynolds has attempted an explanation of the action, supposing it to be due to evaporation and condensation at the surface, but his efforts have been shown to be idle. Mr. Crookes philosophically concludes with the following remarks:—While objecting to the theories already advanced as not accounting for all the facts of the case, the author confesses that he is not as yet prepared with one to put in their place. He wishes to avoid giving any theory on the subject until a sufficient number of facts have been accumulated. The facts will then tell their own tale. The conditions under which they invariably occur will give the laws, and the theory will follow without much difficulty.

ZOOLOGY AND COMPARATIVE ANATOMY.

The Blind-fish, &c., of Kentucky probably of Marine Origin.—An important paper has been published on this subject by Mr. F. W. Putnam in the "Bulletin" of the Essex Institute, U.S.A., and it is abstracted in a recent number of "Silliman's American Journal." The writer observes that many, or, with two or three exceptions, nearly all, of the thirty or forty species of vertebrates, articulates, molluscs and still lower forms, including a few plants, now discovered in the caves of Kentucky, are of comparatively late introduction, is probable from the fact that they are so closely allied to forms living in the vicinity of the caves. But that the blind-fishes, the Chologaster and a few of the lower forms of articulates, as the Lernæan, parasitic on the blind-fish, may have been inhabitants of the subterranean streams for a much longer period, is worthy of consideration on the following grounds:—First, the blind-fish family has no immediate allies existing in the interior water,* the only species of the family, in addition to the three found in the Mammoth Cave, being known at present only from the rice ditches of the low coast of South Carolina. Second, the Lernæan parasite is much more common on marine fishes than on strictly fluviatile species, and is more decidedly a marine than a fresh-water form. These facts may therefore be taken as at least indicating the probability of the early origin of some part of the great Cave system of the region of the Ohio Valley; and while there may be nothing in the present structure of the caves to indicate their having been formed in part while in contact with salt water, the supposed erosion of the limestone and the modification of the early formed chambers by later action should be carefully considered before it can be denied that the caves were not, in some slight part, for a time, supplied with marine life. Until a specimen of Chologaster, or some other member of the family, has been obtained in the external waters of the Ohio Valley, it is hardly logical to regard the family to which the blind-fishes belong as one originally distributed in the rivers of the Ohio Valley, and afterwards becoming exterminated in the rivers, and only existing in two such widely different localities as the coast of South Carolina and the subterranean streams of the south-western States.

The Library of the Zoological Station at Naples.—Dr. Anton Dohrn has issued a Catalogue of the Library of the Zoological station at Naples. Nearly one-half of the volumes belong to Dr. Dohrn, and formed his private library at the time he established the zoological station; the other half consists of works presented either by the publishers or by the authors to the station. As a library of embryological and anatomical works on marine animals, it forms an admirable nucleus for the building up a great zoological library. It only needs the continued interest which has been shown by all working naturalists to supply the station with everything published needed to carry on investigations in every department of zoology. Dr. Dohrn is

* In common with others I have considered the Heteropygii as belonging to the same order with the Cyprinodontes; but I now have, from further information of their structure, doubts as to their close association with that group. This subject will be presented on another occasion.

anxious to secure the co-operation of English and American naturalists, and hopes that they will remember the zoological station in the distribution of their papers.

Specimens of Stylops on Andrena atriceps.—At the meeting of the Entomological Society on May 3, Sir Sidney Smith Saunders, C.M.G., President, exhibited male specimens of Stylops, taken by himself in the pupa state on *Andrena atriceps*, at Hampstead Heath, on the 6th, 9th, and 17th April last. Mr. Enoch, who had been there on the 6th, at an earlier hour (between nine and ten o'clock), had been still more successful, having captured seventeen males; one of which, however, was taken after 2 p.m. The President drew attention to the remarkable difference observable in the cephalothorax of the females in these specimens, as compared with those met with on *Andrena convexiuscula*, and remarked on the importance of avoiding confounding the species obtained from different Andrenæ: *Stylops Spencii* having been described from *A. atriceps*, while *S. Thwaitesii* had been described from *A. convexiuscula*. Mr. Smith believed that eventually a great many species would be found to inhabit this country, and that as many as a dozen different species would probably be found on the genus Andrena alone, independently of those on the genus Halictus.

Gammaridæ in Lake Baikal.—Dr. B. N. Dybowsky has described *ninety-seven* species of Gammarids from Lake Baikal. They include one Swedish species, *G. (Pallassa) cancelloides*; and also the *G. neglectus* of the lake is hardly distinct from *G. pulex*. The species occur at all depths, the greatest depth dredged, 1,373 metres, affording them as abundantly as the littoral zone, though fewer in species. The species of small depths are mostly vividly coloured; those at greater depths are less bright in colour, and the kinds from depths greater than 700 metres are more or less whitish in tint.

Notes on some Parasitic Worms.—At a late meeting of the Philadelphian Academy of Science, Professor Leidy remarked that Mr. Henry Horn, assistant superintendent at the Zoological Garden, had given to him several specimens of worms recently passed by a Bengal tiger. There are three males and eight females, and they appear to be the *Ascaris mystax*, which has been found in many other feline species, including the domestic cat and the lion. The characters of the worms from the tiger are as follows:—Body almost equally tapering towards the extremities. *Female*—Cephalic and inflexed, with long narrow semi-lanceolate alæ. Caudal end straight; tail short, conical, subacute. *Male*—Cephalic end straight, alated. Caudal end inflexed, and furnished with a row of about two dozen minute round papillæ on each side ventrally; tail short, conical, acuminate. Length of females from 2 to $3\frac{1}{4}$ inches; thickness from $\frac{1}{4}$ to $\frac{1}{2}$ line. Length of males from 13 to 16 lines; thickness from $\frac{1}{6}$ to $\frac{1}{5}$ line. Professor Leidy further remarked that Mr. Thomas Meehan had submitted to his examination some worms which had been found in an apple. They consisted of one entire individual and the anterior half of a second, and apparently pertain to the *Mermis acuminata*, a long thread-worm which has been discovered infesting the larvæ of many insects. Among others it is parasitic in the larva of the codling-moth, or fruit-moth of the apple, which readily accounts for its presence in the fruit. Twenty-five years ago (Proc. 1850, 117) he had described a worm, belonging to the collection of the Academy, and labelled as having been obtained

from a child's mouth, which was evidently the same species. It having been in a child's mouth is probably to be explained by supposing that the child had eaten an infected apple.

Do Vertebrate Animals come from Amphioxus?—"The Academy" states (May 29) that the view of most recent zoologists that the origin of the vertebrated subkingdom is to be traced through Amphioxus from the Ascidians, is supported by M. Ussow in the last published part of his "Zoologisch-embryologische Untersuchungen" ("Archiv für Naturgeschichte," 1875, pp. 1-18; "Ann. Mag. Nat. Hist." xv., pp. 321-333). He considers the Tunicata to be quite distinct from the Mollusca both in their embryonal development and in their type of structure. Their closest affinities are with the Bryozoa: but adherence is given to Schmidt's classification, in which they form a distinct class of Proto-vertebrata. Dr. Anton Dohrn advocates a contrary opinion in a memoir entitled "Der Ursprung der Wirbelthiere, und das Princip des Functionswechsels (Leipzig, 1875)." His embryological investigations lead him to seek for the probable ancestors of the higher animals among the Arthropoda rather than the Tunicata, and to revert to the views of the elder St. Hilaire who described insects as vertebrates which run with their back downwards, rather than to those of Kowalevsky and his followers who trace the line through the Ascidians and the lancelet. So far from being the representative of the original vertebrates, the Amphioxus is regarded by Dr. Dohrn as a degenerate descendant of the cyclostomous fish, and the so-called larvæ of the Ascidians are the result of a still longer continued process of degradation. With regard to the principle of change of function, the general rule is laid down that the function of an organ is made up of a principal and other secondary components; if the former decrease in force and the latter increase, the whole function is changed, and the organ itself is altered in consequence.

The Spiders of the Mammoth Cave, U.S.A., have been recently examined by Mr. A. S. Packard, Jun., who states ("American Naturalist's Magazine") "that they occurred more abundantly in all the caves than we expected. The individual abundance was greater in the smaller caverns, especially the Weyer's caves, than any others. In the Mammoth Cave the Anthrobia occurred under stones in dry but not the driest places, on the bottom, at different points in the cave. Sometimes two or three cocoons would be found under a stone as large as a man's head. The cocoons were orbicular, flattened, an eighth of an inch in diameter, and formed of fine silk, and contained from two to five eggs. They occurred with eggs in which the blastodermic cells were just formed, April 25. The eggs were few in number, and seemed large for so small a spider, being $\frac{25}{1000}$ inch in diameter. The chorion is very thin, and finely speckled. The blastodermic cells seemed very large, the largest measuring nearly $\frac{4}{1000}$ inch in diameter. They were round, not closely packed, and showing no indications of being polygonal. They all had a dark, very distinct nucleus. I was unable to trace the development of the young, and ascertain if the embryos are provided with rudimentary eyes. Two young *Anthrobiæ* hatched out May 3 in my room. The whole body, including the legs, is snow white, with the legs much shorter than in the adult. The adult in life is white, tinged with a very faint flesh colour, with the abdomen reddish; in some specimens the abdo-

men has beneath several large transverse dusky bands. The *Linyphia subterranea*, as observed living in Wyandotte Cave, is pale pinkish horn-brown on the thorax and legs, while the abdomen is dull honey-yellow."

The Insects of Kerguelen Island.—At the meeting of the Entomological Society, on May 3, Mr. M'Lachlan read an extract from a report made to the Royal Society on the natural history of Kerguelen's Island, by the Rev. A. E. Eaton, who was attached as naturalist to the Transit of Venus Expedition to the island. Nearly all the insects were remarkable for being either apterous or with greatly abbreviated wings. There were two Lepidoptera, one (only a larva) probably belonging to the Noctuina, the other to the Tineina. Of the Diptera, one species had neither wings nor halteres; another lived habitually on rocks covered by the tide at high water, and its larva fed upon a species of seaweed. All the larger Coleoptera seemed to have their elytra soldered together. Mr. M'Lachlan said that the theory as to the apterous condition of the insects was that the general high winds prevailing in those regions rendered the development of wings useless; and Mr. Jenner Weir remarked that the apterous condition was correlated with the fact that plants under similar circumstances were apetalous and self-fertilising, and hence it was supposed that the existence of winged insects was unnecessary.

Anderson School of Natural History.—Mr. Alexander Agassiz has given the following notice:—"The experience of the past two years has shown that it will be impossible to carry on the School of Natural History at Penikese on the same terms as formerly. At the close of the last session the trustees had exhausted their resources. They propose to charge a fee of fifty dollars for the season of 1875, and to carry on the school during the coming summer if a sufficient number of applications are received in time to make the necessary arrangements. Even with the full complement of students, there will be a considerable deficit (as was the case last year) to be met by the friends of the school, the position of Penikese necessitating many expenses which need not be incurred in a more favoured locality. Applications should be sent at once to the Director at Cambridge, Mass. Preference will be given to teachers and to those who intend becoming teachers."

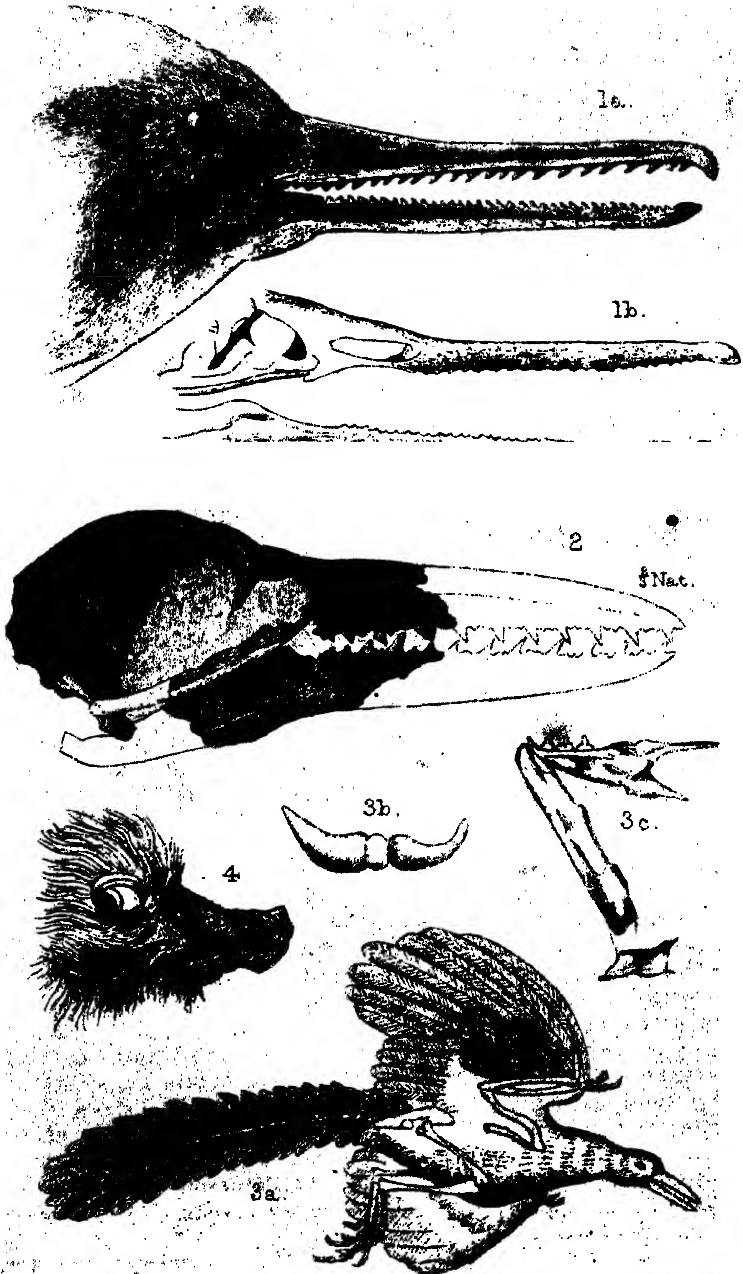
The Naturalists on the Arctic Expedition.—The naturalists appointed to the Arctic Expedition are Mr. H. C. Hart, B.A., and Capt. H. W. Fielden. The former will, we understand, be attached to the *Discovery*, Capt. Stevenson, the latter to the *Alert*, Capt. Nares. Of the four medical officers selected also, one at least has a fair knowledge of natural science.

Notes on the Lygænidæ.—At a meeting of the Linnæan Society, May 6, Mr. A. S. Butler read some notes on the Lepidoptera of the family *Lygænidæ*, with descriptions of new genera and species. The main object of this paper was to rescue this section of Lepidoptera from the confusion into which it had been brought by the creation of new species and genera on insufficient grounds by Mr. F. Walker. Some very curious instances of mimetism were mentioned between parallel series of species of burnet moths and of Hymenoptera.

Completion of Carus' Handbook of Zoology.—This book has, after a lapse of many years, been at length completed. The final issue concludes the

account of the Vertebrata, and treats of the Mollusca and Molluscoida. The publication of the parts of this work has certainly been irregular, the second volume having appeared in 1863, and the first part of the first volume in 1868. The reason of this is now fully explained in the preface. Dr. Peters, of Berlin, who had originally undertaken the Vertebrata, was unfortunately forced by pressure of other occupations first to delay and then to relinquish the execution of the task; and thus, with the exception of the Arthropoda, which were treated of by Herr Gerstaecker, the whole weight of the work eventually fell into the able hands of Professor Carus.

The Development of the Oyster is thus fully given by Mr. Packard (in the "American Naturalist," May 1875). The course of development is thus: After the segmentation of the yolk (morula stage), the embryo divides into a clear peripheral layer (ectoderm), and an opaque inner layer containing the yolk and representing the inner germinal layer (endoderm). A few filaments or large cilia arise on what is to form the velum or the future head. The shell then begins to appear at what is destined to be the posterior end of the germ, and before the digestive cavity arises. At this stage the two-layered germ is said by Salensky to represent the planula of the sponge. The digestive cavity is next formed (gastrula stage), and the anus appears just behind the mouth, the alimentary canal being bent at right angles. Meanwhile the shell has grown enough to cover half the embryo, which is now in the "veliger" stage, the "velum" being composed of two ciliated lobes in front of the mouth-opening, and comparable with that of the gastropod larvæ. The young oyster, as figured by Salensky, is directly comparable with the veliger of the cardium. We have, then, three stages of growth in the oyster: (1) the morula, (2) the gastrula (with the digestive cavity as yet undeveloped), and (3) the veliger with an alimentary canal and a head and hind body (cephalula). This is an epitome of the mode of development of most of the lamellibranchiate molluscs whose embryology is known. Soon the shell covers the entire larva, only the ciliated velum projecting out of an anterior end from between the shells. In this stage the larval oyster leaves the mother and swims around in the water, the cilia of the velum keeping up a lively rotary motion. In this state Lacaze-Duthiers observed it for forty-three days, without any striking change in form, except that the velum increased in size, and the auditory vesicle appeared, containing several otoliths, which kept up a rapid motion. But still the gills and heart were wanting. Of its further history we know but little, except that it becomes fastened to some rock and is incapable of motion. The oyster is said, by the appearance of its shell, to be three years in attaining its full growth; but this statement needs confirmation.



G. M. Woodward del. W. West & Co sc.

Birds with Teeth.

BIRDS WITH TEETH.

By HENRY WOODWARD, F.R.S., F.G.S., Etc.

OF THE BRITISH MUSEUM.

[PLATE CXXV.]

ONE of the greatest difficulties which the systematic naturalist meets with in the examination of the fauna of a new country is that his old ideas of classification are perpetually shaken by contact with new and strange life-forms, whose places are the more hard to fix in proportion to the procrustean character of the system into which he strives to fit them.

Nor can he escape from the dilemma by refusing to admit them altogether, like Dr. Shaw in the days of old, who (so the story goes), on finding a shell, not described in Linnæus's "Systema Naturæ," gave it a rap with his hammer and brushed it away!

But, great as are his difficulties, they are light compared with those which the palæontologist encounters as he exhumes the fragmentary relics of bygone faunas, and strives by the help of existing organisms to rehabilitate the crumbling remains of a former world. For he knows that the vast assemblage of living forms which he sees around him to-day have sprung, by descent, from the earlier life of the past, and that consequently no system of classification can be deemed complete unless it embrace both Neozoic and Palæozoic faunas, linking together in one wide and comprehensive scheme the living present with the dead and far-off past.

In striving to attain to this much-to-be-desired classification, however, a serious obstacle arises from our very imperfect knowledge of the greater number of extinct animals, especially those belonging to the higher forms. Of their soft parts we can know but very little, whilst with the skeleton itself we are, as a rule, only able to attain to a very imperfect acquaintance. There is perhaps no order of animals to which these remarks apply with greater force than to that of Birds.

Although their remains in a fossil state are but few in number, they nevertheless possess a remarkable degree of interest which even the more abundant relics of other classes cannot supersede.

Ornitholites have been met with in at least a dozen different localities in the Tertiary deposits of Europe, and also at two or three places in our own island.

Specimens have been obtained from the Miocene of Allier in France, which M. Alphonse Milne-Edwards * has referred to about seventy species of birds of various groups, some of which do not belong to the present fauna. Parrots and Trogons inhabited the woods; the edible swifts built their nests among the rocks; a "secretary bird," a marabout stork, a flamingo, an ibis, and other birds served to give to these localities in early Miocene times a strikingly South African *facies*. The bird-bones of the Mayence Basin present a complete similarity to those of Allier.

Bird-remains occur also in the Miocene of Œningen, near the Lake of Constance; in the Upper Eocene of Puy de Dôme, Perignat, and Auvergne; from the Eocene of Montmartre and Meudon, near Paris, whence M. Alphonse Milne-Edwards has also determined several new genera of birds, as the *Cryptornis* and the *Palæogithalus*, whilst the *Gypsornis* is described as the giant of the family of "Rails," being as large as a stork. From our own Eocene of Hordwell and Sheppey Prof. Owen has recorded the genera *Halcyornis* and *Lithornis*; also a large struthious bird of the size of the living ostrich (the *Dasornis Londiniensis*), and a still more remarkable bird, the *Odontopteryx toliapicus*, to be presently referred to more fully.

With the two exceptions of the Eocene slate-rocks of the Canton Glaris, in which the almost entire skeleton of a small passerine bird, about the size of a lark, has been discovered, and the gypsum quarries of Montmartre, where two or three connected skeletons of different species of birds have been found, these remains consist of detached bones or fragments only, or of eggs or feather impressions.†

Parts of a large "fossil" bird have been obtained from the Sewalik Hills, India; whilst Madagascar has yielded to the studies of M. Alphonse Milne-Edwards and others, remains of three species of *Æpyornis*, whose affinities are clearly recognisable with the *Dinornis* and *Apatornis* of New Zealand.

In the recent deposits of the Mascarenes the remains of the

* "Annales des Sciences Naturelles," 1871, sér. 5, Zoologie, tom. xvi.

† See "Ueber Fossile Eier und Federn," von Hermann von Meyer, "Palæontographica." Cassel, (1865–68), pp. 223–259, pl. 36–38, in which eggs and feathers are described and figured from about ten separate localities.

extinct Dodo, Solitaire, *Aphanapteryx*, giant gallinule, parrots, &c., mark the last representatives of the terrestrial fauna of a once extensive continent, now submerged save the islands of Mauritius, Rodriguez, and Bourbon. But the majority of these, like the extinct wingless birds of New Zealand, the *Dinornis*, with the *Apatornis defossor* (Owen), the *Notornis Mantelli* (Owen), the great extinct goose, *Cnemiornis calcitrans* * (Owen), and the gigantic penguin, *Palæeudyptes antarcticus* † (Huxley, discovered by Dr. Hector), and an extinct gigantic bird of prey, the *Harpagornis* Moorei, Haast,‡ may have lived down to the time of man's advent; nor do they offer any remarkable peculiarities which might justify their separation from existing birds.

Formerly the remains of a "longipennate natatorial bird, equalling the albatross in size,"§ were recorded from the chalk of Burham, near Maidstone; but these relics are now referred to *Pterodactylus giganteus*, the largest and the last form of flying reptile known in the history of the crust of this earth.‖

Among the numerous fragmentary vertebrate remains from the Cambridge greensand—a formation most extensively worked for phosphate of lime for artificial manure—the late Mr. Lucas Barrett in 1858 discovered the remains of a bird rather larger than the common pigeon, and probably belonging to the order *Natatores*, and, like most of the gull tribe, having well-developed wings. Portions of the metacarpus, metatarsus, tibia, and femur have been detected, and the determinations of Mr. Lucas Barrett have been confirmed by Professor Owen.¶

That the existence of birds at the period of the formation of the Secondary rocks should have been first made known by their footprints may seem strange; but as far back as 1835 a notice appeared in Silliman's "American Journal of Science" of the discovery by Dr. Deane of impressions resembling the feet of birds upon some slabs of New Red Sandstone from the Connecticut Valley in the United States.

Prof. Hitchcock was the first who submitted these tracks to a careful scientific investigation, and he concluded that they

* "Trans. New Zealand Inst." 1874, vol. vi. p. 76, pl. x–xiii.

† Op. cit. 1872, vol. iv. p. 341, pl. xvii. and xviii.

‡ Op. cit. 1874, vol. vi. p. 62, pl. vii. and viii.

§ "Geol. Trans." 1840, 2nd series, vol. vi. p. 411.

‖ Owen's "Palæontology," 2nd edition, 1861, p. 275.

¶ Lyell's "Manual," 6th edition, 1865, p. 330. By an error, Mr. Lucas Barrett, F.G.S., figures in Lyell's "Elements" as "*M. Louis* Barrett." Barrett was born in London, and was for some time curator of the Woodwardian Museum, and afterwards appointed Director of the Geological Survey of the West Indies, where he was unfortunately drowned.

furnished evidence of the footprints of no less than *thirty-two species of* BIPEDS, and twelve quadrupeds. Thirty are believed to be birds, four tracks of lizards, two of chelonians, and six of batrachians. The tracks have been found over an extent of nearly eighty miles north and south, and in more than twenty places. They are repeated through a succession of beds attaining at some points a thickness of more than 1,000 feet, and occupied, doubtless, thousands of years in formation.*

More than 2,000 impressions have been examined by Prof. Hitchcock:—

"The bipedal impressions are for the most part *trifid*, and show the same number of joints as exist in the feet of living tridactylous birds.

"Such birds have three phalangeal bones for the inner toe, four for the middle, and five for the outer one, but the impression of the terminal joint is that of the nail only. The fossil footprints exhibit regularly, where the joints are seen, the same number; and we see in each continuous line of tracks the three-jointed and five-jointed toes placed alternately outwards, first on one side and then on the other. In some impressions, beside the three toes in front the rudiment of the fourth toe is seen behind.

"It is not often that the matrix has been fine enough to retain impressions of the integument or skin of the foot; but in one specimen found by Dr. Deane at Turner's Falls, on the Connecticut River, these markings are well preserved, and have been recognised by Prof. Owen as resembling the skin of the ostrich, and not that of reptiles.

"Among the supposed bipedal tracks the feet of a single distinct animal only has been observed, in which there are four toes directed forwards. In this case a series of four footprints is seen, each twenty-two inches long and twelve wide, with joints much resembling those in the toes of birds."†

Assuming the correctness of the opinion long ago expressed by Dr. Mantell, and subsequently by Prof. Leidy of Philadelphia, Prof. Huxley, and others, that *Iguanodon*, *Hadrosaurus*, as well as other of the monstrous land-lizards of the Secondary rocks, may have supported themselves, for a time at least, upon their hind legs, then some of these remarkable bipedal tracks may be referred to the Reptilia.‡

The discovery by Mr. S. H. Beckles, F.R.S., in the slabs of ripple-marked sandstone, near Hastings, of pairs of large three-toed footprints of such a size and at such a distance apart, that it

* Hitchcock, 1848. "Mem. Amer. Acad." new series, vol. iii. p. 120.

† Lyell's "Elements," 6th edition, 1865, p. 453.

‡ See "Quart. Journ. Geol. Soc." 1874, vol. xxx. p. 8.

is difficult to believe them to have been made by anything but Iguanodon,* lends further confirmation to this conclusion.

The first evidence of the existence of a bird in strata of Oolitic age was furnished by the discovery of the impression of a single feather in a slab of lithographic stone from Solenhofen, described and figured by Hermann von Meyer in 1861.†

To this fossil impression H. von Meyer gave the name of *Archæopteryx lithographica.*

Later on, in the same year, Professor Andreas Wagner communicated to the Royal Academy of Sciences in Munich the discovery (in the same formation at Solenhofen) of a considerable portion of the skeleton of an animal with impressions of feathers radiating fanwise from each anterior limb, diverging obliquely in a single series from each side of a long tail.

Dr. Wagner's paper (written shortly before his death) was wholly founded on the reports of M. Witte of Hanover and Dr. Oppel of Munich. From their information he was led to conclude that the affinities of this wonderful creature were strongest to the Reptilia, and he regarded its natural covering as merely "presenting a deceptive resemblance to feathers," and named it *Griphosaurus.*

Hermann von Meyer concluded that the impressions represented actual feathers, and that the single feather, already noticed by him, doubtless belonged to the same animal. But, even so, they need not necessarily be derived from a bird. Indeed, the feathered fossil from the lithographic stone of Pappenheim, in Dr. Haberlein's collection (of which he had also heard) differed essentially from our birds, and need not necessarily be a bird. The simple tarsus (writes von Meyer) shows that the animal does not belong to the Pterodactyles, and the formation of the tail contradicts the idea that we connect with our birds, yet the feathers are undistinguishable from those of birds.

Happily for British palæontologists, this remarkable avian fossil was secured for our national collection in 1862, and a memoir thereon was presented to the Royal Society by Professor Owen,‡ and read on November 20 of that year.

I also published a figure, and gave a brief account of the *Archæopteryx* in the "Intellectual Observer" for December 1862 (vol. ii. p. 314).

The specimen is preserved in intaglio and relievo on two slabs of Solenhofen limestone, the lower of which, doubtless, represents the ancient surface of what was once tidal mud,

* See "Quart. Jour. Geol. Soc." 1862, vol. xviii. p. 248.

† "Jahrbuch für Mineralogie," 1861, p. 561.

‡ See "Phil. Trans." 1863, p. 33, pl. 1-4.

upon which the bird was left at the time of its death, the upper being composed of the layers deposited by subsequent tides, and to which we are indebted for the preservation of the fossil.

The impressions of the feathers are most beautifully preserved upon the lower slab, exhibiting the tail and wings and some further portions of the skeleton itself. The head, neck, and dorsal vertebræ are wholly wanting. The right scapula and humerus and both the fore-arms are well preserved. Two of the digits of the wing appear to have been free, and armed with sharp recurved claws.

In modern birds the anterior of the three digits of the pinion remains free, and in some species supports a claw or spur, *e.g.* the Syrian blackbird, spur-winged goose, the "Jacana"; the Screamer (*Palamedea cornuta*) has two spurs; the Megapode has a tubercular rudiment of a pinion (Owen).

The lower right limb is well preserved, consisting of femur, tibia, and tarso-metatarsal bones; to the latter bone four toes are articulated, one hind toe and three fore toes, having severally 1, 2, 3, and (4?) joints as in all birds, and armed with strong recurved claws. The foot agrees well with that of a true perching-bird, but from the fanwise and rounded arrangement of the wing-feathers it would appear to have been a bird of feeble flight.

On the occasion of the reading of Professor Owen's paper, November 20, 1862, Mr. John Gould, F.R.S., the ornithologist, expressed the opinion that the wings of the *Archæopteryx* were not adapted for flight.

The most singular and unavian characteristic of this Oolitic bird is its tail, which is complete, and consists of twenty narrow elongated vertebræ, the dimensions of which slowly, but constantly diminish, so that the last is the smallest. The feathers of the tail are attached in pairs to each vertebra throughout its entire length.

In most recent birds, we find the tail very short and powerful, composed of vertebræ, varying from five to nine in number, having well-developed spinous processes on their upper and under side—the last vertebra being very peculiarly formed, and, with few exceptions, *always the largest.* This last joint, called the ploughshare bone or *os coccygis*, is composed of two or more coalesced vertebræ, and gives attachment to the retrices or rudder quill-feathers of the tail, and supports the coccygeal oil-glands.

"With the exception of the caudal vertebræ," writes Professor Owen, "and possibly the biunguiculate and less confluent condition of the manus, the parts of the skeleton preserved in this

rare feathered fossil animal accord with the strictly ornithic modifications of the vertebrate skeleton."

But he adds: "All birds in their embryonic state exhibit the caudal vertebræ distinct, and, in part of the series, gradually decreasing in size to the pointed terminal one.

"In Archæopteryx the embryonal separation persists with such continued growth of the individual vertebræ as is commonly seen in tailed vertebrates, whether reptilian or mammalian."

Professor Owen concludes his able memoir thus:—"By the law of correlation we infer that the mouth was devoid of lips, and was a beak-like instrument fitted for preening the plumage of *Archæopteryx*," &c.

Among the many careful investigators who examined the *Archæopteryx* from day to day after the arrival of the fossil bird, and still more after the reading of Professor Owen's paper, none took a more lively interest in it than Mr. John Evans, F.R.S., the present President of the Geological Society of London.

It was by Mr. Evans's exertions that a rounded nodular mass (see Plate, fig. 3 *b*.) standing up in relief from the surface of the slab, attained the honourable comment from Professor Owen that it "may be, as suggested by Mr. John Evans, F.G.S., part of the cranium with the cast of the brain of *Archæopteryx*."

It may be well here to state that, having once arrived at the idea that this was a cast of the cerebral hemispheres of the brain of *Archæopteryx*, Mr. Evans gave orders to his game-dealer to send him every queer bird that came to hand, and as in winter we have, from our insular position, the strangest assortment of marsh-loving birds shot and sent to the London market that are perhaps to be met with anywhere, Mr. Evans was soon fully employed. Each bird's cranium was carefully cleaned out, and a cast of the interior made by pouring liquid plaster of Paris into it through the foramen-magnum. When set, the skull was cut across so as to remove the upper and anterior portion and expose the cast of the interior for comparison. One of these casts of skulls (that of a carrion crow) so prepared is figured in "The Geologist," vol. vi., for January 1863.* I believe the one which Mr. John Evans conceived to be nearest in form to the cast of the brain of the *Archæopteryx* was a cast of the brain-cavity of a woodcock. I allude to it,

* Another of these casts—cast of the fore part of the brain of a magpie (*Corvus pica*)—is figured by Professor Owen on the plate of *Archæopteryx* which accompanies his Memoir, but by an oversight has not been credited to Mr. Evans.

however, merely in passing, as collateral evidence in favour of a still bolder proposition put forward by that gentleman with regard to another stray fragment preserved on the slab on which the Archæopteryx reposes. This is referred to in the explanation of Plate 1 of Professor Owen's memoir as "fig. 3 *p'*, Premaxillary bone, and fig. 1 *p*, its impression, resembling that of a fossil fish."

Mr. John Evans has published a very interesting account of his investigation of this little fossil jaw, which appeared in the "Natural History Review," * from which I shall venture to make a few extracts. Mr. Evans writes:—

"On the principal slab in the angle between the right femur and tibia is a small V-shaped object; the longer of the two limbs about 1½ inches in length, made up partly of mineralised bone and partly of impressions of other portions of the same bones preserved in the counterpart slab. From its form it had, I believe, been considered as possibly representing the beak of the *Archæopteryx*; but great was my surprise when I detected along its right hand margin, towards the apex, the distinct impression in the slab of four teeth still attached to it. The teeth themselves remain adhering to the counterpart, and are easily recognised by the lustre of their enamel. There seems also to be a portion of a fifth tooth visible, which has been displaced and lies across the base of that nearest the point of the jaw. The portion of the jaw to which they are attached is unfortunately much injured, and there is no appearance of any teeth in connection with the other limb of the V." (See Plate CXXV., fig. 3 *c.*).

Whether the whole is a lower jaw, with the teeth, or rather a few of them, remaining in one half only, and with the symphysis of the jaw at the point of the V; or whether it is a portion of an upper jaw in which the second limb of the V would be probably part of the facial and nasal bones, I cannot pretend to determine; and I am afraid that the whole is in too fragmentary and obscure a condition for any positive conclusions to be drawn on this point.

The character of the teeth, however, appears to me to be well defined. The three which remain in a vertical position with regard to the jaw are about 0·10 inch long, and at intervals of about 0·20 inch. They consist of a slightly tapering flattened enamelled crown, about 0·04 inch in width, and obtusely pointed, set upon what is apparently a more bony base which widens out suddenly into a semi-elliptical form, so that at the line of at-

* "On Portions of a Cranium and of a Jaw in the Slab containing the Fossil Remains of the *Archæopteryx*." By John Evans, F.R.S., F.G.S. "Natural History Review," July 1865, p. 415.

tachment to the jaw the base of one tooth comes in contact with that of the next. So sudden and extensive is this widening of the base that at first it gave me the impression that the teeth were tricuspidate with the middle cusp far longer than the others.

The front tooth of the four, which slopes forward from the rest, and is rather smaller than the others, shows little if any similar enlargement of its base. Of the fifth, which lies across the base of the foremost of the other four, only a part is visible. There appears to be a well-defined line at the base of the teeth along their junction with the jaw; but I can offer no opinion as to the method of their attachment. It is of course contrary to all our existing notions to suppose that a jaw, such as this, armed with teeth, could belong to a creature so truly bird-like in most respects as the Archæopteryx; but assuming it to be that of a fish—and it has many analogies with the jaws of some species of fish—or of some other animals accidentally deposited in the very midst of the remains of that singular creature, it appears to me that, fragmentary as it is, its characters are sufficiently defined for any one well versed in the fossils of the Solenhofen slate to come forward and identify it.

Up to the present time, however, I have not heard of any one having been able to do so, and certainly the jaws and teeth of the *Lepidotous* and *Pholidophorous* fishes from the same beds, such as I have been able to examine, all differ from this in some more or less important particulars. It appears to me also that the teeth and jaw of the Archæopteryx slab are rather slighter in structure than those of fishes of corresponding size, though this is a point on which I would by no means insist.

Looking at the usual dispersion of the fossils in the Solenhofen slates; looking also at the general rule (to which, however, there are some exceptions) that the fossils in it are found singly, so that all the remains of a reptile or a fish upon a single slab may usually be assigned with some degree of confidence to a single individual, the chances against a single extraneous jaw being mixed up with the remains of the Archæopteryx, without any other bones of the animal to which the jaw belonged being also present, are great indeed. But how enormously are the chances against such an occurrence increased if the jaw thus accidentally present is that of a species of fish or reptile hitherto unknown.

In order to secure the best possible information on this point, a careful drawing was made of the little jaw and submitted to the illustrious Hermann von Meyer, who replied from Frankfort, April 4, 1863, as follows:—

"In Palæontology it is difficult to judge from drawings, but the two supplementary objects which Mr. John Evans has succeeded in discovering upon the *Archæopteryx* slab are certainly

of the greatest importance. Upon the part which may belong to the hinder part of the skull I hazard no opinion. Much more important is the jaw. Teeth of this sort I do not know in the lithographic stone. There exists no similarity between them and the teeth of Pterodactyles. The nearest likeness is to the teeth of my family of *Acrosaurus*, namely, to the *Acrosaurus Frischmanni*, Meyer ("Reptilen des Lithog. Schiefers," p. 116, t. 12, f. 7–8), from the lithographic slate of Bavaria, in which however the crown is lower and longer from back to front. In *Pleurosaurus Meyeri* ("Palæontographica," x. p. 37, t. 7) which belongs to the same family, the teeth possess less likeness. One might also be reminded of the teeth of the *Geosaurus Soemmeringi*, Meyer ("Deutsch. Akad. Munich," 1816, p. 36; Cuvier, Oss. foss. pl. 249, fig. 2–6), which, however, are much longer.

"From this it would appear that the jaw really belongs to the Archæopteryx. An arming of the jaw with teeth would contradict the view of the Archæopteryx being a bird or an embryonic form of bird. But, after all, I do not believe that God formed his creatures after the systems devised by our philosophical wisdom. Of the classes of birds and reptiles as we define them, the Creator knows nothing, and just as little of a prototype, or of a constant embryonic condition of the bird, which might be recognised in the Archæopteryx. The Archæopteryx is of its kind just as perfect a creature as other creatures, and if we are not able to include this fossil animal in our system, our short-sightedness is alone to blame."

It will, of course, be observed that this opinion of Von Meyer is founded on my drawings alone, and is therefore of course subject to a revision on an examination of the slab itself. But there certainly appears to be a case made out for careful investigation by those more competent than I am to form an opinion in such a case. Its extreme importance as bearing upon the great question of the origin of species must be evident to all, and I for one see no reason why a creature presenting so many anomalies as the Archæopteryx, all of which, however, tend to link together the two great classes of birds and reptiles, should not also have been endowed with teeth, either in lieu of, or combined with a beak, in the same manner as in *Rhamphorhynchus*, with which it exhibits other affinities. The tooth-like serrations in the beaks of many birds—and notably in the *Merganser serrator*—where they closely approach in character to real teeth, though connected only with the horny covering and not with the bones of the mandible, are sufficient to prove that the presence of feathers does not of necessity imply that the beak with which to preen them should be edentulous.

A reference to our figure of the *Merganser* (Plate CXXV.,

fig. 1 *a*), well illustrates this point; and on referring to the skull (Plate CXXV., fig. 1 *b*) it will be seen that each serration on the beak of the Merganser has its corresponding denticle on the mandibular border of both the upper and lower jaws. Such another bird, with more powerful tooth-like serrations on its mandibles than are possessed by the Merganser, has lately been figured and described by Professor Owen from the London clay of the Isle of Sheppey, which has already yielded to the same distinguished comparative anatomist an ostrich, a vulture, a kingfisher, a small wading-bird, and numberless remains of Mammalia and Reptilia of the greatest interest to the palæontologist.

This bird, the *Odontopteryx toliapicus* of Owen, is represented by a single skull,* which we reproduce on a reduced scale on Plate CXXV., fig. 2, has the bony denticles inclined at a considerable angle, their points being directed towards the anterior extremity of the beak in both the upper and lower jaw, whereas in the Merganser they incline inwards towards the articulation of the jaws. In the fossil skull the tooth-like serrations vary, larger and longer teeth alternating at intervals with more numerous shorter ones.

Professor Owen concludes "that *Odontopteryx*, like *Archæopteryx*, was a warm-blooded feathered biped, with wings; and, further, that it was web-footed and a fish-eater, and that in the catching of its slippery prey it was assisted by this pterosauroid armature of its jaws."†

Having thus, with the assistance of Professor Owen, disposed of the difficulty arising from the law of correlation, which requires that a beak and feathers should be associated together; and having shown that both a fossil and a recent bird had undoubted tooth-like serrations to their mandibles, let us next enquire whether the assumed possession of teeth coated with enamel and implanted in sockets (such as those which have been attributed to *Archæopteryx*. See Plate CXXV., fig. 3 *c*.) by Mr. John Evans, are irreconcilable with the undoubted fact that it was an animal clothed in feathers.

Referring to Professor Owen's "Comparative Anatomy and Physiology of Vertebrates," 1866, vol. ii. chap. 17, p. 145, under the sub-heading "Beaks of Birds," is the following:—

"In place of teeth these bones are provided with a sheath of horny fibrous material, similar to that of which the claws are

* The discovery of the ornithic character of this fossil, and the working out of the teeth, are due to my esteemed colleague in the Geological Department, Mr. William Davies, who has added so much to our knowledge of extinct life-forms among the Vertebrata.

† "Quart. Journ. Geol. Soc." 1873, vol. xxix. p. 520.

composed: this sheath is moulded to the shape of the osseous mandibles, being formed by a vascular substance covering these parts, and its margins are frequently provided with horny processes or laminæ secreted by distinct pulps, analogous in this respect to the whalebone laminæ of the whale." To this is added the subjoined singularly apposite quotation from Geoffroy St. Hilaire, Ét. "Système Dentaire des Mammifères et des Oiseaux," 8vo, 1824:—

"In a fœtus of a parroquet, nearly ready for hatching, the margins of the bill are beset with white and round tubercles, arranged in a regular order, about seventeen in the upper jaw, the foremost on the mid-line. These tubercles are not indeed implanted in the alveolar border, but form part of the sheath of the bill. Under each tubercle, however, there is a gelatinous pulp, like that of a tooth, but resting on the edge of the jawbones, and every pulp is supplied by vessels and nerves traversing a canal in the substance of the bone. These tubercles form the first margins of the mandibles, and their remains are indicated by canals in the horny sheath subsequently formed, which contain a softer material, and which commence from small foramina in the margin of the bone."

If, then, we accept Professor Owen's interpretation as regards the embryonal character of the long tail and the free digits of the wings in *Archæopteryx* that it is a true bird, but with "a retention of a structure embryonal and transitory in the modern representatives of the class and a closer adhesion to the general vertebrate type," then it is fair to assume that the presence of teeth in the mandible of such a bird is equally admissible both on the evidence furnished by the embryo of a living bird, the parroquet, and also on the grounds of a closer adhesion to the general vertebrate type.

But, it may be urged, "your proposition that the *Archæopteryx* had teeth is a pure assumption. Show me some evidence of a fossil bird whose head and skeleton are in juxtaposition so as to leave no reasonable doubt of their unity." Happily for our argument, this is exactly what Professor O. C. Marsh has succeeded in doing in the case of two distinct bird-remains from the Cretaceous shale of Kansas.* "The type species of this group, *Ichthyornis dispar* (Marsh), had well-developed teeth in both jaws. These teeth were quite numerous, and implanted in distinct sockets. They were small, compressed, and pointed, and all of those preserved are similar. Those in the lower jaws number about twenty in each ramus, and are all more or less inclined backward. The series extend over the

* "On a New Sub-class of Fossil Birds" (*Odontornithes*). By Professor O. C. Marsh, Yale College, Ct., U.S.A. "Silliman's Journal," vol. iv. p. 344, Oct. 1872, and vol. v. p. 74, Jan. 1873.

entire margin of the dentary bone, the front tooth being very near the extremity. The maxillary teeth appear to have been equally numerous, and essentially the same as those in the mandible. The skull was of moderate size, and the eyes were placed well forward. The lower jaws are long and slender, and the rami were not closely united at the symphysis. They are abruptly truncated just behind the articulation for the quadrate. This extremity, and especially its articulation, is very similar to that in some recent aquatic birds. The jaws were apparently not encased in a horny sheath.

"The scapular arch, and the bones of the wings and legs, all conform closely to the true ornithic type. The sternum has a prominent keel, and elongated grooves for the expanded coracoids. The wings were large• in proportion to the legs, and the humerus had an extended radial crest. The metacarpals are united, as in ordinary birds. The bones of the posterior extremities resemble those in swimming birds. The vertebræ were all biconcave, the concavities at each end of the centra being distinct, and nearly alike. Whether the tail was elongated cannot at present be determined, but the last vertebræ of the sacrum was unusually large. The bird was fully adult and about as large as a pigeon. With the exception of the skull, the bones do not appear to have been pneumatic, although most of them are hollow. The species was carnivorous and probably aquatic. The possession of teeth and biconcave vertebræ, although the rest of the skeleton is entirely avian in type, obviously implies that these remains cannot be placed in the present group of birds, and hence a new sub-class, *Odontornithes*, is proposed for them. The order may be called *Ichthyornithes*." The other form discovered by Professor Marsh is named by him *Apatornis celer*.

Much surprise has been expressed at the non-publication of these remains with figures, but when it is borne in mind that Professor Marsh has been carrying on the exploration of these vast Cretaceous deposits in a wild and unsettled country *alone*, and that he has further attempted the almost impracticable task of working them out with his own hands, we are the less surprised to learn from him that he has failed in securing an artist to delineate them satisfactorily. Professor Marsh is a veritable Crusader in Palæontology, and Yale College may well be proud of him; but we hope he will, for the sake of science, attempt less hazardous enterprises among the restless Indians of Kansas, and be satisfied to work out and publish the splendid mass of materials which he has already accumulated, and for which English palæontologists are craving.

From birds with persistent embryonic characters, in head, hand, and vertebral column, to bipedal Reptilia, seems but a natural step, and it is not surprising to find that the subject has

been carefully considered by Professor Huxley, whose views have already appeared in the "Popular Science Review" for 1868, vol. vii. p. 237, Plates XXVII. and XXVIII., which we earnestly commend to the attention of readers of this article.

The question—"What is a bird, and what is a reptile?" is one only of the many difficult problems which zoologists are called upon to answer. Its solution is, however, hopeless only to the mind prejudiced against all innovation, and which prefers to erect harsh barriers, whereas Nature, who blends the colours of the rainbow, knows no such abrupt limits.

If in this article we have been enabled to show not only that there have been feathered bipeds with teeth, but also that it is still possible to treat them at least as a sub-class of birds, our object will be achieved.

P.S.—Just as this article was passing to press I learn from Prof. Marsh that he will figure *Ichthyornis* in "Silliman's American Journal" for October next. He adds: "I have re-examined *Hesperornis*, a large diving bird nearly six feet high, found in the same cretaceous formation in Kansas as the *Ichthyornis*, and I find it also has *teeth in both jaws*, not in sockets like *Ichthyornis*, but in grooves as in *Ichthyosaurus*." (Sept. 20, 1875.)

EXPLANATION OF PLATE CXXV.

Fig. 1*a*. Head of *Merganser serrator*, drawn from a specimen in the British Museum.*

Fig. 1*b*. Skull of same, showing denticles on mandibular border.*

Fig. 2. Skull of *Odontopteryx toliapicus*, Owen, from the London clay, Sheppey (two-thirds natural size).

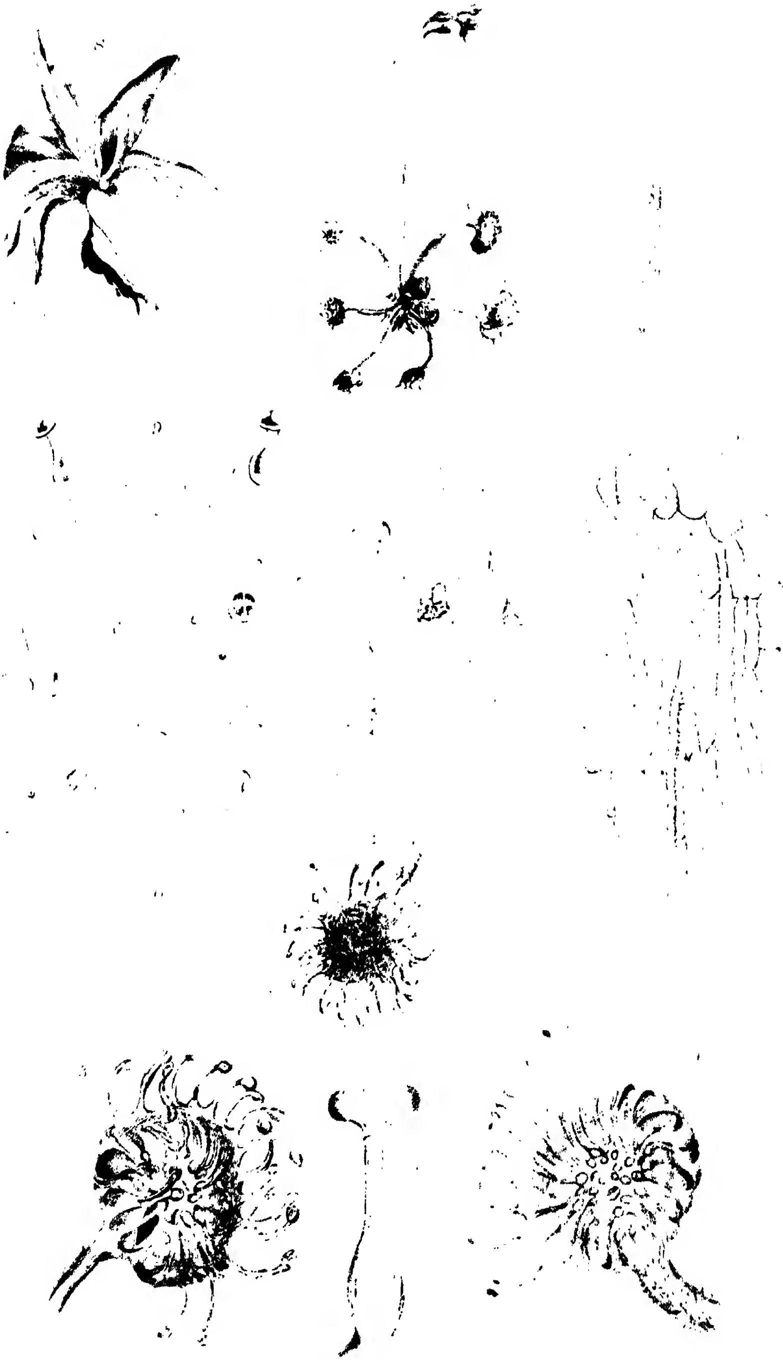
Fig. 3*a*. *Archæopteryx macrura*, Owen; a restoration, copied from Professor Owen's "Comparative Anatomy of Vertebrates," vol. ii. p. 586. (In the original woodcut the mandibles are represented as *serrated*.)

Fig. 3*b*. Rounded and bilaterally symmetrical body, found on the slab with the *Archæopteryx*, from the lithographic stone, Solenhofen, and attributed to the cast of brain-cavity by Mr. John Evans, F.R.S., President Geological Society, London.

Fig. 3*c*. Small jaw, with teeth, also found associated on the same slab with, and attributed to *Archæopteryx*, by the late H. von Meyer.

Fig. 4. Head of gosling before hatching, clothed with long down (or hair?), and with the horny knob at the end of the beak, with which it breaks the shell when arrived at full time. (Suggestive, possibly, of further persistent embryonal characters.) Copied from Professor Owen's "Comparative Anatomy," vol. ii. p. 264.

* For permission to examine and draw figs. 1 *a* and 1 *b*, I am indebted to the kindness of Dr. A. Günther, F.R.S., Keeper of the Zoological Department, British Museum.



CARNIVOROUS PLANTS.

By ALFRED W. BENNETT, M.A., B.Sc., F.L.S.

LECTURER ON BOTANY, ST. THOMAS'S HOSPITAL.

[PLATE CXXVI.]

OLD landmarks are fast being obliterated. In former times the mind even of the most scientific was trammeled by the idea that nature could be mapped out into districts, like squares upon a chess-board, each bordered by a well-marked line of circumvallation, and standing in a perfectly definite relation to the squares on either side. The objects of nature were supposed to be classified, not by man but by the Creator of all things, in accordance with a certain preconceived and often most fantastic ideal. It is only within a comparatively short time that our views on this head have undergone a radical change. The general acceptance of the theory of evolution has given a final blow to the old idea. Classification is now but a human contrivance for tabulating the links in the endless chain which connects together all living things. The lines on the chess-board have disappeared, and have given place to the imperceptible gradations of the colours of the rainbow. While we can still define red and yellow, and distinguish one from the other, we must admit a wide debatable border-land of orange.

This change affects not only the ultimate, but even the primary distinctions between organic beings. Even the division of animate nature into the two kingdoms of animal and vegetable is no longer unchallenged. No other naturalist of mark has, it is true, followed Haeckel in erecting a third kingdom out of the simplest forms of the other two. It is rather that not a single one of the characters which have formerly been relied on to distinguish animals from vegetables has passed unscathed through the crucible of modern research. The power of spontaneous, or at least of apparently spontaneous motion, which was formerly considered to belong exclusively to animals, is now known to be possessed in an equal degree by many of the most lowly vegetable organisms, and even to be apparently a universal

property of living protoplasm, whether animal or vegetable. We were taught in our childhood that while animals inhale oxygen and exhale carbonic acid, the respiration of plants is of an exactly opposite character; vegetable physiologists now tell us that the true process of respiration which all plants perform consists, like that of animals, in an exhalation of carbonic acid gas. It was formerly believed that starch was never produced by animals, while it is always formed by plants at some period of their existence; we now know that fungi never produce starch, while on the other hand it has been found in the tunics of the Salpæ. Even the last refuge of those who still maintained the essential distinction of the two kingdoms—that the food of animals is organic while that of plants is inorganic—must now be abandoned.

This is, however, no recent discovery in particular cases. The plants known as parasites, whether phanerogamic or fungi, the mistletoe and dodder, or the potato-blight and mildew, live entirely on the already assimilated food-materials found in the tissues of the "hosts" on which they are parasitic. But in all these instances the nutritive material is absorbed by the plant in a manner similar to that in which the majority of vegetables derive their nourishment from the soil; in the case of flowering plants through root-like organs or "haustoria," and in the case of fungi through a mycelium, which penetrates deeply into the tissue of the host. The point of greatest interest to physiologists in the facts brought out in Dr. Hooker's inaugural address to Section D, at the meeting of the British Association at Belfast, in 1874, and more recently in Mr. Darwin's latest publication,* is that certain plants have the power of absorbing the material required for their food—not only through the root, but also through the tissue of the leaf by means of certain special organs, aided by most elaborate and beautiful mechanical contrivances. The first announcement of this fact was the more startling, inasmuch as the most recent experiments appear to have demonstrated that leaves are quite incapable, except under the most exceptional circumstances, of absorbing pure water, either in the liquid or gaseous condition.

The number of genera in which this power has been demonstrated with more or less certainty is about thirteen, ten of which are described more or less minutely in Mr. Darwin's work. Of these genera three only are British; two of these have species which are common and readily accessible, and to them we propose mainly to direct attention in the present paper.

Few lovers of plants have not gathered and admired the

* "Insectivorous Plants." By Charles Darwin, M.A., F.R.S., &c. London: J. Murray, 1875.

pretty little *Drosera*, or Sundew, a denizen of bogs, with its small red leaves clothed with glands which are apparently always wet with dew on the hottest summer day, and elegant scape of minute white flowers, opening only in the brightest sunshine. The commonest species *D. rotundifolia*, with round leaves, is found in sphagnum and peat-bogs throughout the country, and is especially common in all our sub-alpine districts. Two other species are British, *D. intermedia* and *anglica*, both with linear-oblong leaves, the latter much the larger plant, but are much scarcer; the former, however, grows as near London as close by the Burnham Beeches in Buckinghamshire, intermixed with *D. rotundifolia*, and is abundant in the New Forest. On closer examination it is seen that the minute drops which hang on the glands are not dew, but consist of a viscid fluid stretched in threads from one to another; and that numbers of minute insects are captured in it and firmly held down by the enfolding of the glands over them.

The leaf is indeed a veritable fly-trap. If a specimen is planted in a saucer in damp sand, and a minute insect placed on a leaf which was before quite free, the glands will be seen to bend over it, commencing with the ones nearest to those that actually touch it, until at length every gland on the leaf has become inflected, and the insect is hopelessly imprisoned. Long before this it has, however, probably almost ceased to move; and that the movement of the glands is not the result of mechanical irritation from the struggles of the insect—like that of the stamens of *Berberis*—is proved by the fact that the outermost marginal glands do not fold over until the struggles of the insect have ceased. Fig. 1, Plate CXXVI., shows a plant of *Drosera rotundifolia* about the natural size; fig. 2, one of the leaves magnified about twice; fig. 3, a leaf with an insect just captured; fig. 4, one in which nearly all the glands are folded over, both multiplied about four times; and fig. 5, one of the glands on a much larger scale.

The mechanism of the movement of the "tentacles," as Darwin terms these organs, has been closely investigated by him and others. Each tentacle consists of a stalk or pedicel, composed of several rows of elongated cells, with a roundish or ellipsoidal dark-red gland at its extremity. The gland is seen under a high magnifying power to be pitted or honeycombed; and the pedicels, as well as the upper surface of the leaf where not occupied by the tentacles, is provided with a number of minute papillæ, consisting of several cells. The morphological nature of the tentacles has been a subject of much discussion. Trécul, Warming, and other observers have clearly shown that, at least as regards some of them, especially those at or near the margin of the leaf, they are an integral part of the leaf itself,

as is proved by their being traversed throughout their length by a fibro-vascular bundle containing spiral threads. Fig. 6 is copied from a drawing of Warming's, representing the internal structure of one of these organs. I am inclined to think, however, from an examination of a number of leaves in a very early stage of development, that this is not the history of all the tentacles; but that a number of them are true "trichomes," or epidermal structures. That organs which closely resemble one another outwardly and perform similar functions, should not all have the same morphological origin, is not without parallel in the vegetable kingdom. The terminal glands are seen, when the plant is in a healthy and vigorous condition, to exude a quantity of a viscid secretion which can be drawn out into long threads; and the quantity of this secretion is greatly increased by contact with organic matter.

If an object capable of exciting the motion is placed in the centre of a leaf, the whole of the tentacles of the leaf gradually converge towards it, and finally completely envelope it. If, on the contrary, the object is placed on one of the marginal glands, this tentacle only first of all bends over towards the centre of the leaf carrying the object with it; and then the same inflection occurs of the remaining leaves. The inflection takes place in the lowest portion of the pedicel only, the remaining part of the pedicel and the gland itself remaining perfectly straight. The exudation of the viscid secretion is however from the gland only; and Mr. Darwin records in his work some very remarkable facts connected with the change that takes place in the protoplasm contained in the various cells of the pedicel. In a leaf when in the normal condition, the cells of the pedicel are filled with a homogeneous purple fluid. This appearance undergoes a great change after the gland has been excited by repeated touches or by contact with an organic substance. The cells have then a mottled appearance even to the naked eye, owing to the colouring matter becoming aggregated into purple masses of various shapes, which now float in an almost colourless fluid. This aggregation of the purple matter commences in the cells immediately beneath the gland, whence it travels down to the base of the pedicel; the little coloured masses constantly changing their form, separating and reuniting with a motion similar to that of an Amœba or of the white corpuscles of the blood.

The aggregation of the protoplasm and the inflection of the tentacles are independent of one another, and are both brought about by a variety of causes—concussion of the gland, the pressure of solid particles of any kind, absorption of solid substances, and by a certain degree of heat. Any solid particle allowed to rest on a gland or a number of glands will produce inflection; but if

the particle is inorganic the effect is only slight, and the tentacles soon resume their normal position. With organic substances, and especially minute living animals, the case is very different; the embracing motion of the tentacle is compared by Darwin to that of the tentacles of a polyp when seizing its prey; and they do not again unfold until the substance is partially or entirely absorbed. The behaviour of the leaves with fluids is still more remarkable. Distilled water produces no effect whatever. This might be expected; but it is more noteworthy that the same is the case apparently with all organic but non-nitrogenous fluids. In sixty-one experiments recorded in Mr. Darwin's work, with gum-arabic, sugar, starch, dilute alcohol, olive oil, and a decoction of tea, the tentacles were not inflected in a single case. The case is very different with all nitrogenous fluids. Milk, albumen, infusion of meat, mucus, saliva, and isinglass, produced inflection in every instance, after a longer or shorter time. In fact the leaves of *Drosera* furnish a test for nitrogen in solutions, rivalling in delicacy any of the performances of the spectroscope. Experiments, which were repeated over and over again to ensure accuracy, and with the utmost care to eliminate every possible source of error, show that the $\frac{1}{14,400}$ of a grain (·00445 milligram) of carbonate of ammonia absorbed by a gland, is sufficient to induce inflection in the basal part of the same tentacle; and, if immersed in a solution of this substance for a few hours, the same effect is produced by the $\frac{1}{268,800}$ of a grain (·00024 mg.). Immersion in nitrate of ammonia of such strength that each gland can absorb only the $\frac{1}{691,200}$ of a grain (·0000937 mg.) excites movements in each tentacle. With phosphate of ammonia the result is still more extraordinary. A minute drop containing $\frac{1}{153,600}$ of a grain (·000423 mg.), if held for a few seconds in contact with a gland, causes the tentacle bearing this gland to be inflected. If a leaf is immersed for a few hours, and sometimes for a shorter time, in a solution so weak that each gland can absorb only the $\frac{1}{19,760,000}$ of a grain (·00000328 mg.), this is enough to excite the tentacle into movement, so that it becomes closely inflected.

The facts connected with the list of non-nitrogenous substances which cause and which do not cause inflection of the tentacles are very curious. Nine salts of soda with which Mr. Darwin experimented all caused inflection, while none of seven corresponding salts of potassa did so; the salts of metals as a

rule caused inflection; as did nineteen out of twenty-four organic and inorganic acids, the exceptions being gallic, tannic, tartaric, citric, and uric, none of which acted as poisons. The action of alkaloids and organic poisons was very various; strychnine, digitaline, and nicotine are poisonous, and produce inflection, as does hydrocyanic acid very rapidly; while morphia, hyoscyamus, atropine, veratrine, colchicine, curare, and dilute alcohol are not poisonous, and have no power, or only a very slight one, of inducing inflection. The vapours of chloroform, and sulphuric and nitric ether, act in a singularly variable manner, sometimes producing extraordinarily rapid inflection; but further experiments on this point seem required.

The mode of transmission of the motor impulse from one gland to another is a very curious and intricate branch of the subject. From the facts already mentioned it would appear that the glands, together with the cells of the pedicel lying immediately beneath them, are the sole seat of the irritability or sensitiveness of the leaves; and the impulse has to be transmitted down nearly the whole length of the pedicel before inflection takes place. But this motor impulse is transmitted from the gland immediately excited to others which are not in contact with the exciting substance; and in the tentacles thus indirectly excited the aggregation of the protoplasm always commences also in the cells immediately beneath the gland. Mr. Darwin terms this process a reflex action, and compares it to the irritation of a sensory nerve, by which, when an impression is carried to a ganglion, some influence is sent back to a muscle or gland, causing movement or increased secretion. He believes that the motor impulse is not transmitted, at least exclusively, through the spiral vessels or the tissue immediately surrounding them, but through the cellular tissue, and more rapidly in a longitudinal than in a transverse direction. I am inclined to think, from experiments of my own, that it is possible that, at least in some instances, the impulse may be transmitted, not through the tissue of the leaf at all, but through the viscid secretion; as in some instances I have found tentacles on one leaf to be inflected by contact with excited tentacles belonging to another leaf, where there is nothing to cause inflection in the first. One of the most remarkable circumstances connected with these phenomena is the fact that after leaves have been detached from the plant, they do not in any degree lose the power of inflection and aggregation of the protoplasm inherent in the tentacles for many hours or even days; a strong indication that they possess some power of imbibing nutriment independent of the root.

All that we have related so far would by no means prove a true process of digestion on the part of the sundew. It might

be possible—and indeed this has been maintained by some—that these arrangements were merely a contrivance for facilitating the decay of the living insects or other entrapped organic substances; and that the nutrient matter resulting from their decay, being carried to the ground, fed the plants through the ordinary medium of the rootlets. To Darwin must be assigned the merit of having for the first time clearly and unmistakably demonstated a true process of digestion carried on by the foliar organs of plants; although Dr. Hooker and others had earlier given good reason for a belief in its existence in the case of *Nepenthes* and other pitcher plants. The viscid secretion from the glands of *Drosera* is, in the normal condition, nearly or quite neutral to test-paper. But as soon as it is excited by contact with any inorganic or organic substance, it becomes distinctly acid, and more strongly so after the tentacles have remained for some time closely clasped over any object. A small quantity of the substance thus obtained was sent for analysis to Professor Frankland, who found no trace of hydrochloric, sulphuric, tartaric, oxalic, or formic acid; but, as far as could be determined from the very minute quantity submitted to analysis, distinct indications of an acid belonging to the acetic or fatty series, probably propionic, with a possible admixture of acetic and butyric. A still more interesting result of Mr. Darwin's experiments was the conclusion that in addition to the acid a substance analogous to pepsin, and acting as a ferment, is secreted by the glands, but only when excited by the presence of digestible, *i.e*, nitrogenous, matter. This singular result, affording so striking an analogy to the phenomena of digestion by the stomach of an animal, is in harmony with the observation of Dr. Hooker in the case of *Nepenthes*, that the fluid formed in the pitchers of that plant entirely loses its power of digestion when removed from the pitcher and placed in a glass vessel, although it is even then distinctly acid. The following substances were found to be completely dissolved in the secretion, viz., albumen, muscle, fibrin, areolar tissue, cartilage, the fibrous basis of bone, gelatin, chondrin, casein in the state in which it exists in milk, and gluten which has been subjected to the action of weak hydrochloric acid; while epidermic productions, fibro-elastic tissue, mucin, pepsin, urea, chitine, cellulose, gun-cotton, chlorophyll, starch, fat, and oil, are not acted on either by the secretion of *Drosera*, nor, as far as is known, by the gastric juice of animals.

The power possessed by *Drosera* of obtaining nourishment through the leaves receives confirmation from a valuable series of experiments by Dr. Lawson Tait,* who announced, inde-

* See "Nature," for July 29, 1875.

pendently of Mr. Darwin, the separation of a substance closely resembling pepsin from the viscid secretion of *Drosera dichotoma*. He placed side by side plants of the common *Drosera rotundifolia*, some in the normal state, others with the roots pinched off close to the rosette, and with the leaves all buried, only the budding flower-stalk appearing above the sand; others with the roots and flower-stalk left on, but all the leaves pinched of, the roots being buried in the sand; and others again with the roots left on but appearing above the sand, some of the leaves buried and others exposed. These plants were all carefully washed with distilled water, before being planted in silver sand which had deen deprived of all organic matter, carefully watched to prevent flies being caught; and were then fed, some with pure distilled water, others with a strong decoction of beef, and others with a very dilute solution of phosphate of ammonia. The conclusions arrived at from the series of experiments were that the plant can not only absorb nutriment by its leaves, but that it can actually live by their aid alone, and that it thrives better when supplied with nitrogenous material in small quantity. The nitrogenous matter is more readily absorbed by the leaves than by the roots, over-feeding killing the plant sooner through the leaves than through the roots alone; although the roots also certainly absorb nitrogenous matter. This absorption of nutrient material through the leaves is in harmony with the fact already mentioned, of the vitality of the leaves long after separation from the plant.

We are not acquainted with any special organ by which the processes of absorption and digestion are effected; indeed, almost everything connected with their *modus operandi* remains for the present in obscurity. It seems likely that the papillæ which abound on the upper surface of the leaf and on the pedicels of the tentacles have some share in them; and possibly also certain other bodies which are not described by Mr. Darwin, nor by any other observer as far as I am aware. These bodies, which I propose provisionally to call "ganglia," are represented in fig. 7, and are found, on making a careful dissection of the leaf, immediately beneath the epidermis of the upper surface, and on the pedicels of the tentacles. They consist of from two to four cells, much smaller than the ordinary cells of the mesophyll of the leaf, and have the appearance of centres from which the cell-walls radiate. They are filled with a brownish-green granular, presumably protoplasmic substance. I have not observed bodies of a similar character except in plants* whose foliar organs possess the power of digestion.

* With the exception of *Callitriche*, in which bodies of a similar character produce the so-called "rosulate" appearance of the leaves, and were long ago described as glands by the late Dr. E. Lankester.

The genus *Pinguicula* belongs to a natural order widely separated from *Drosera*. The Butterworts are all, like the sundews, natives of bogs, and are so called from the greasy texture of the thick leaves, caused by the viscid glands with which the upper side of the leaf is studded. The commonest species, *P. vulgaris*, fig. 8, is a very familiar plant by the side of streams and in other wet places in all the mountainous districts of our islands; but its deep blue flowers have passed away by the middle of summer. A second species or sub-species, *P. grandiflora*, with much larger blue flowers, is confined to the south-west of Ireland; and *P. alpina*, with nearly white flowers, to the most alpine parts of Scotland; while the fourth British species, *P. lusitanica*, with small lilac-yellow flowers, is abundant in the south-west of England, and the west of Scotland and Ireland.

The contrivance for capturing insects is very different in the case of *Pinguicula* to that which we have described in *Drosera*. The whole of the upper surface of the leaf is studded with a number of glands composed of a stalk or pedicel, which consists of a single cell, and of a flat capitate head, formed of a number of small cells, usually eight or sixteen; their mode of growth is represented in fig. 9, magnified; and a single one on a much larger scale in fig. 10. They are always secreting a large quantity of an extremely viscid fluid, neutral to test-paper; but have no power of motion when excited; the only movement in the leaf of the butterwort being a very slow incurving of the margin over any imprisoned object. The extreme viscidity of the secretion from the glands is the sole means by which the entrapped animals are detained. The incurving of the margin is caused either by the pressure of any solid particle, or by contact with a digestible substance, whether solid or in solution; but after a comparatively short time the margin again unfolds.

The general results of Mr. Darwin's observations on *Pinguicula vulgaris* amount to this:—Objects not containing soluble matter have little or no power of exciting the glands to increased secretion; while dense nitrogenous fluids cause the glands to pour forth a large supply of viscid fluid, which is still not acid. On the other hand the secretion from glands excited by contact with nitrogenous solids or liquids is not only very copious, but is invariably acid. The secretion in this state has the power of rapidly dissolving and digesting the tender part of the bodies of insects, meat, cartilage, albumen, fibrin, gelatine, and caseine. The secretion which has absorbed nitrogenous matter is quickly re-absorbed by the glands, which change their colour from green to brownish, and contain masses of aggregated granular, presumably protoplasmic matter, while no such effect is produced by the action of non-nitrogenous fluids.

The phenomena exhibited by the butterwort have not, how-

ever, received nearly so much attention as in the case of the sundew; although the larger size and more transparent nature of the glands, and the firmer and thicker tissue of the leaves rendering it easier to obtain thin transparent sections, make it in some respects more favourable for observation. A section which exposes the epidermis of the upper surface of the leaf, reveals bodies of a similar nature, and possibly with a similar function to those which I have described as "ganglia" in the case of *Drosera*. Two of these bodies are represented in fig. 11. They are circular, and are divided by septa radiating from the centre usually into four, less often into six or eight cells, filled with protoplasm, and containing a few grains of chlorophyll. They closely resemble the heads of the glands, and, like the corresponding bodies in *Drosera*, may possibly be glands arrested in their development. *Pinguicula lusitanica*, which is more easily obtained in the south of England, exhibits the same phenomena as *P. vulgaris*, but rather more strongly.

Having now described somewhat in detail the phenomena presented by our most familiar British species of carnivorous plants, we will refer more briefly to those which are less known, or are natives of other countries. The species which can at present certainly be ranked under this category, are comprised in four natural orders—widely separated from one another in other points of structure, viz., Droseraceæ, Lentibulariaceæ, Nepenthaceæ, and Sarraceniaceæ.

Among Droseraceæ, the genus *Drosera* includes, besides the British species already described, a considerable number distributed over the greater part of the surface of the globe. All of these which have been examined in the fresh state display peculiarities similar to those of our country, some of them apparently with a greater intensity. A North American species, *D. filiformis*, is described by a careful observer, Mrs. Treat,* as growing in such abundance in parts of New Jersey as almost to cover the ground, and the detaining power of the leaves as being sufficient to entrap even moths and butterflies. An Australian species, *D. dichotoma*, has leaves, including the foot-stalk, 27 in. in length.

Another plant of very great interest belonging to this order is the well-known Venus's fly-trap, *Dionæa muscipula*, not unfrequently seen in cultivation in this country, though growing wild in a very limited area on boggy ground in the eastern part of the state of North Carolina. The arrangements for capturing insects are here altogether different from those found in the allied genus. The secreting glands are extremely minute, and exude the viscid fluid only after being excited by the presence

* "American Naturalist," Dec. 1873.

of a digestible substance, and have no power of motion. The faculty of detention lies in the elasticity of the tissue of the leaf itself. On the upper surface are six strong hairs or bristles which display extraordinary sensitiveness, conveying to the rest of the leaf an irritation when touched, which causes the leaf suddenly to fold up, the sharp serrations or spikes with which the margin is covered closing upon one another, and interlocking like the teeth of a rat-trap. The glands, which are in this instance true epidermal structures, secrete an almost colourless, slightly mucilaginous, strongly acid fluid, but only when excited by the presence of nitrogenous matter, which they have the power of absorbing. This secretion, the formation of which is seen, from what has been said, to be altogether independent of the mechanical irritation of the leaves, appears, from Mr. Darwin's experiments, to have a distinct power of digestion. The most remarkable fact connected with *Dionæa* is in the difference in the behaviour of the leaves after closing, according to whether a digestible substance, an indigestible substance, or nothing at all, has been captured. In the two latter cases the leaves reopen in less than twenty-four hours, and are then again at once sensitive to renewed impact. In the first case, on the contrary, they remain closely shut up for many days, and after re-expanding are torpid, and never act again, or only after a very considerable interval of time. Moreover, when the leaf is made to close over an insect or other body containing soluble nitrogenous matter, the two lobes, instead of remaining concave, as they otherwise do, enclosing a small cavity, slowly press close together throughout the whole of the blade with very considerable force, and offer very great resistance to any attempt to force them apart. Mr. Darwin draws some very interesting conclusions from these facts; showing how this arrangement allows small insects to escape before they are crushed and thus yield up their nutrient juices, while larger insects are hopelessly entrapped; the digestive process being therefore only brought into play when a considerable quantity of nutriment is at the command of the leaf. Dr. Burdon Sanderson has made the additional extremely curious observation * on the Venus's fly-trap, that a normal electrical current traverses the blade and the foot-stalk of the leaf, while the current is reversed when the leaves are irritated or the foot-stalk cut. The phenomena therefore present a most remarkable analogy to those which occur in the muscles of animals when contracted; although there does not appear to be anything whatever in the *Dionæa* which can in any way be compared to the nervous tissue of animals.

* "Proceedings Royal Society," vol. xxi. p. 495; and "Nature," 1874, pp. 105 and 127.

Besides *Drosera* and *Dionæa*, there are four other genera included in the order Droseraceæ, viz., *Aldrovanda*, *Drosophyllum*, *Byblis*, and *Roridula*, all of which capture insects; and in all of them the phenomena of absorption and digestion have either been observed or may be fairly inferred. The first of these genera includes only a single species, *A. vesiculosa*, occurring in three somewhat distinct forms in Europe, India, and Australia. It is a small water-plant, with two-lobed leaves, having the peculiarity of suddenly closing on irritation similar to that of *Dionæa*, and furnished with long jointed hairs, which are apparently sensitive. Of the remaining three genera, one is European, another South African, and the third Australian. The first only has yet been examined in the growing state, and bears a strong resemblance to *Drosera*, except that the tentacles have no power of movement.

To the order Lentibulariaceæ belong the four genera, *Pinguicula*, *Utricularia*, *Polypompholyx*, and *Genlisea*, all carnivorous. The genus *Utricularia*, or Bladderwort, is a very interesting one, and includes three or four British species, plants found in ditches, often of fetid water, with elegant yellow flowers on slender stalks, and floating deeply-divided leaves furnished with little bladders, from whence the plant derives its name. These bladders have been recognised by several observers, Mr. R. Holland in this country and Mrs. Treat in the United States, as fly-traps, and their structure has been closely investigated by Mr. Darwin in the case of the commonest British species, *U. vulgaris*, and its variety or sub-species *U. neglecta*. The bladders are about one-tenth of an inch in diameter, are provided with a number of long bristles or "antennæ," and are closed by a valve which is attached on all sides to the bladder, except by its posterior margin, which is free, and forms one side of the slit-like orifice which leads into the bladder. The valve is covered on the inner surface with a number of glands which secrete, but apparently have no power of absorption. The margin of the valve rests on the edge of a rim or collar, which allows the valve to open inwards only. By this contrivance a large number of aquatic animals are entrapped—insects, Entomostraca, and even worms, as well as innumerable Algæ and Infusoria; and obviously, when once captured, cannot again escape. Mr. Darwin's observations serve to show beyond doubt that the bladders have the power of absorbing nitrogenous substances, which they doubtless derive from the decay of the imprisoned animalcules; but he does not consider that they have any power of digesting animal matter analogous to that possessed by the plants already described. This absorption he believes to be effected by certain peculiar bodies described by him as "bifids" and "quadrifids." These bodies line the whole

of the inner surface of the bladders, and consist of four, less often of two, divergent arms or cells. The mode in which they act is not clear; but it is demonstrated that they possess the faculty of absorbing nitrogenous matter, salts of ammonia, or infusion of meat. Bodies of a somewhat similar character were observed by Mr. Darwin in the case of *Aldrovanda*, where he at one time conjectured that they performed the function of absorbing the indigestible portion of the food. I can scarcely doubt that they are homologous with the bodies described by me as "ganglia" in *Drosera*, and especially in *Pinguicula*, the function of which is at present unknown. May they not be rudimentary "quadrifids"?

A very remarkable species of bladderwort, *U. montana*, a native of tropical South America, is not aquatic, but is said to be epiphytic. The bladders, which are extremely minute, are borne on the underground thread-like rhizomes, and are produced in extraordinary numbers. They are closed by a valve on which are a number of minute glands, and bear internally rows of short, thick, quadrifid processes; and apparently capture and detain a number of minute insects, on which the plant feeds. This is the only species of *Utricularia* which is not aquatic or a native of marshes. *U. nelumbifolia* has the very singular habit of growing in the water which collects in the bottom of the leaves of a large *Tillandsia*, inhabiting an arid rocky part of the Organ Mountains, Brazil, at an elevation of 5,000 ft. above the sea. It propagates itself by runners, which direct themselves towards the nearest plant of *Tillandsia*.

Polypompholyx is a native of Western Australia, and *Genlisea* of Brazil. In this last genus some of the leaves are elongated into a very narrow cylinder, half an inch to an inch in length, in the middle of which is a minute swelling or tubercle, in which organic matter is found. The neck of the cylinder is furnished with rows of bristles attached to ridges and pointing downwards, which would effectually prevent the escape of any insect that may descend the neck into the utricle, and with a number of quadrifid cells or processes, very closely resembling those already described in *Pinguicula*, the function of which can only be conjectured.

The order Nepenthaceæ comprises the single genus *Nepenthes*, which includes a considerable number of species, mostly natives of the East Indies and Australasia, and well known in hot-houses in this country as "Pitcher-plants." The pitcher consists partly of the leaf-stalk and partly of the blade of the leaf, and contains in its lower portion, to the depth of an inch or more, a fluid which was formerly believed to be nearly pure and potable water; but analysis shows it to contain in solution a considerable proportion of mineral salts. Buried in this fluid is fre-

quently found a great mass of dead flies and other insects, which have been apparently lured into the pitcher by the secreted fluid; and, their escape being prevented by a rim furnished with bristles pointing downwards below its mouth, have there miserably perished. It was determined by Dr. Hooker that the fluid is distinctly acid, and that it possesses the power, not merely of hastening the decay, but of actually digesting the bodies of the insects drowned in it. He also made the additional remarkable observation that when removed from the pitcher and placed in a glass vessel, although still acid, it has entirely lost its power of digestion. This singular fact is interpreted by Mr. Darwin—and with great probability—to indicate that the actual agent in the digestion is a ferment of a nature similar to pepsin, which is secreted only during the absorption of some digestible nitrogenous substance. In the walls of the pitchers of *Nepenthes* are minute bodies resembling and possibly homologous to the "quadrifids," or rudimentary papillæ of *Genlisea* or *Pinguicula*.

To the last order, Sarraceniaceæ, belong the three genera *Sarracenia*, *Darlingtonia*, and *Heliamphora*, natives of America, also cultivated in this country under the name of "Side-saddle plants." The pitchers in this instance consist of the convoluted stalk of the leaf only, the blade forming the lid. They have not at present been subjected to the same careful examination as *Nepenthes*; but, from the observations of Dr. Hooker, Dr. Canby, and others, there is little doubt that they will be found to present very similar phenomena.

From the fact that the plants we have now passed under review belong to families very widely separated from one another on any system of classification, it is highly probable that phenomena of a similar character still remain to be discovered in other groups of the vegetable kingdom. Although, as we said at the outset, the assimilation of animal food by plants is no newly discovered fact, it must still be admitted that the series of observations here recorded—and especially the apparent production by vegetables of a digestive ferment performing all the functions of pepsin in the animal economy—form one of the most important and interesting additions to our knowledge of vegetable physiology that have been made for many years.

EXPLANATION OF PLATE CXXVI.

FIG. 1. *Drosera rotundifolia*; natural size.
FIG. 2. A leaf, × 2.
FIG. 3. A leaf, with imprisoned insect; the tentacles partially inflected, × 4.

FIG. 4. A leaf, with nearly all the tentacles closely inflected, × 4.
FIG. 5. A tentacle, greatly magnified.
FIG. 6. Internal structure of tentacle, showing spiral vessels.
FIG. 7. Section exposing under surface of epidermis of upper side of leaf; *a*, stomata; *b*, "ganglia," or arrested papillæ.
FIG. 8. *Pinguicula vulgaris*; natural size.
FIG. 9. Portion of upper surface of leaf, with two glands, magnified.
FIG. 10. Gland, greatly magnified.
FIG. 11. Section exposing under surface of epidermis of upper side of leaf; *a*, stomata; *b*, "ganglia," or arrested papillæ.
FIG. 6 after Warming, the rest from nature.

OUR SUBMARINE DEFENCES.

By Captain C. ORDE BROWNE, R.A. [Retired].

[PLATE CXXVII.]

IN the spring of 1873 our equipments of torpedo warfare were fully reviewed,* including both the fixed explosive engines, known as submarine mines, and those of a locomotive character to which the word "torpedo" has been more peculiarly applied. During the two years that have since elapsed, some progress has been made in the development of the latter class of destructive engines. Whitehead's fish torpedoes have been manufactured in considerable numbers, and their powers have been increased, especially in the most important matter, that of speed in their "running." In short, both Whitehead's and Harvey's torpedoes have received much attention, and they have been brought to greater perfection. Nevertheless, no change has taken place in either of them of such a character as to call for special notice. This is not the case with the first class of engine mentioned, namely, submarine mines. With these a remarkable series of experiments has been carried out, known as the *Oberon* experiments, the result of which has been to prove that our whole system of submarine mines must be changed. In fact, at this moment we may look upon ourselves as in a state of transition from one system to another, although the substance of the Committee report is not yet made known.

The *Oberon* experiments were instituted to ascertain, as exactly as possible, the effect of a submarine mine exploding at various distances from a vessel of the modern type. For this purpose the *Oberon* was fitted with a bottom and sides resembling those of H.M.S. *Hercules*, and was "tested to destruction," as the phrase is; that is to say, she was exposed to the action of the class of mine proposed to be adopted generally for our lines of defence, at first at a considerable distance, but gradually brought nearer to the vessel until she should be completely disabled from further action. The experiments were

* *Vide* "Torpedoes,' by A. Hilliard Atteridge. "Popular Science Review," April 1873.

very complete and well carried out, and it is hardly necessary to add, were very costly.

The system of mines which it was then proposed to employ in defence of harbours generally consisted of lines of ground charges of compressed gun-cotton, of 500 lbs. each, the depth of water for which such charges were best suited being about eight fathoms, and this depth is a very common one. The charges were to be in galvanic connection with the look-out stations or firing-points, so as to enable them to be fired at the will of an operator; self-acting gear, to explode them on contact with an enemy's ship, being also provided. The object of the experiments was to ascertain the distance at which a vessel would be destroyed by the explosion of a mine, and also the necessary interval between the mines, to secure each one from the effects of explosion of those contiguous to it. It is obvious that a certain relationship must exist between these distances respectively, for while it is imperative that the channel should be completely closed against the entrance of an enemy, it is most desirable that the first explosion should not extend beyond the mine acting on the vessel, because it would open a wide gap in the line of defence. With a single line of mines it would be necessary that the interval which would be sufficient to prevent injury from an adjacent explosion should not, under any circumstances, be more than double the distance at which the destruction of a vessel might be considered certain. As, however, channels are defended by several lines of mines, those forming one line covering the intervals in the line next in front, the conditions become modified to a certain extent. Altogether it was scarcely questioned that an efficient system of defence, with large ground charges of 500 lbs. of cotton, might be organised; and if so, this was for many reasons to be preferred to the alternative system, consisting of numerous small charges floated close to the surface of the water, on which we shall have to say more hereafter.

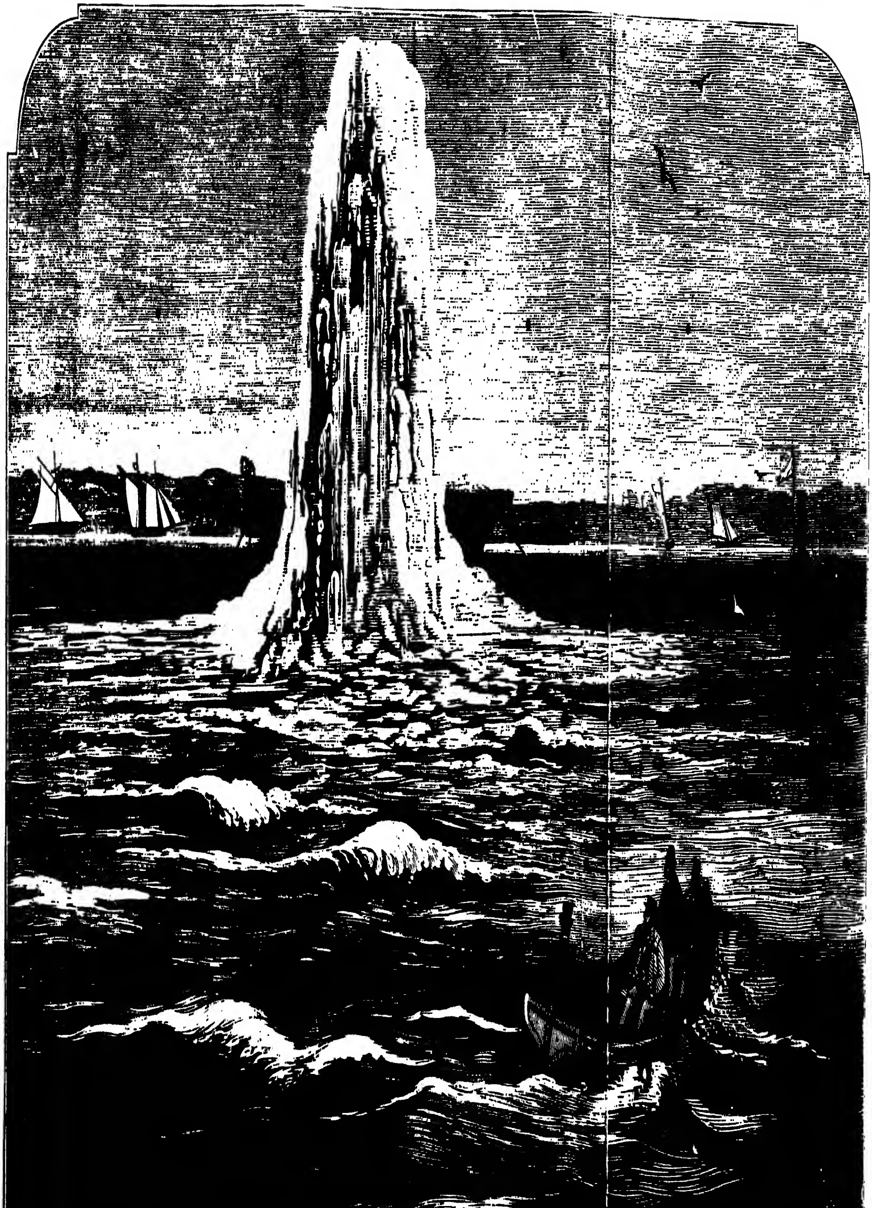
On August 6 the first experiment took place, at Stokes Bay, under the direction of the Special Committee, of which Sir W. Jervois is president. We give the details of this trial, as obtained from official sources, and published at the time in the "Engineer," the editor of which periodical has kindly placed the information and cuts herewith at our disposal.

The *Oberon* was in the following condition:—The inlet and outlet valves of her condensers were left open. The Kingston valve of her feed-pipe was closed. The water-line was 2 inches higher than the top of her condenser. The original weight of her hull, before fitting her with special bottom, had been 590 tons; as now fitted, it was 920 tons. Her cables and condensers weighed about 80 tons. Her starboard side had forty-

four crusher gauges, each crusher piston ⅜ square inch in area; behind it was a lead pellet hardened with antimony. Over each side of the vessel were suspended six 18-pounder shot, also fitted with crusher gauges. The object of these preparations was to put the vessel into the condition representing that in which an enemy's ship might receive the attack. It had been urged that a specially vulnerable point was to be found in the condensers and their fittings. Hence the attention given to them. With respect to the weight of the vessel, it will be readily seen that in the kind of attack that was to be made the inertia of the vessel affected the question directly. If a small charge, and such as might be driven against the side of a vessel by a locomotive torpedo, were exploded in contact with the ship's side, the effect would be localised, and the weight of the vessel under these conditions would not enter into the question; for the blow delivered is of such a character that the vessel cannot escape injury in any degree by being lifted or moved. The whole effect, whatever it be, must be expended on the part of the ship presented to it. It is otherwise with a large ground mine. The charge being exploded perhaps 50 feet from the ship's side, in place of a small force acting on a surface of a few superficial inches, the ship receives the effect of a much greater blow, but already distributed not exactly over the surface of a sphere of 50 feet radius, but in a somewhat similar manner. Water being incompressible, delivers the blow of the explosion well; being, in fact, compelled to move to make room for the gas suddenly generated. With an incompressible medium round it laterally and earth beneath, it is evident that the only direction in which movement is possible is upward; and the water being lifted more directly and easily, just in proportion as it is situated more nearly above the charge, the chief displacement is directly upwards, a mass of water being driven into the air, as shown in Plate CXXVII., which is a sketch made from the actual jet of water thrown up on the occasion of the first *Oberon* experiment, but which equally well represents that of almost any submarine explosion.

From this it follows that the blow falling on a ship consists in a sudden forcing of the water against a large part of the side or bottom, and it is evident that the damage done to her may be less in the case of a light ship that moves readily than a heavy one. A ship heavily weighted with armour, then, would expose her bottom to a more severe shock than any other class of vessel. The *Oberon*, consequently, did not perfectly represent an armour-clad vessel, although her bottom corresponded to that of the *Hercules*, but she probably was sufficiently like to answer the purpose in view. The object of the crusher gauges was to register the pressure of the water in all directions, with

To face p. 368.



EXPERIMENT ON THE "OBERON."

a view to the probable action on the "circuit-closers" of mines in the vicinity.

A charge of 500 lbs. of gun-cotton saturated with fresh water was placed in the service-pattern iron case, on the ground, at 100 feet from the vessel's side, where the depth of the sea was about eight fathoms (*vide* No. 1 in fig. 2). It was not expected that this first experiment would severely try the *Oberon*; the intention of the programme was to begin at the greatest distance where an effect might be reasonably expected, and work gradually nearer and nearer. The progress of the successive experiments may be seen in fig. 2, where the situation of each charge, with the date of the trial, is noted beneath it. The gun-cotton was used wet. This did not concern the object of this experiment, but incidentally it may be noticed that the effect of gun-cotton exploded wet is about the same as that of dry cotton. It was mentioned in the article on torpedoes referred to (POPULAR SCIENCE REVIEW, April 1873), that gun-cotton could be exploded in a wet state, by means of a powerful detonator. The explanation appears to be that the vibration or wave of explosion generated by detonation differs so far from that of explosion by heat, that water is unable to absorb or take it up. Thus while heat has to overcome water by turning it into steam and expelling it at the loss of all the heat, specific and latent, required for such a process, the wave or explosion of detonation passes through it, unimpeded, just as completely as light passes through a glass window.

We have given the details of the experiment of Aug. 6 at some length because they apply, with but little variation, to the entire series. The following summary may be given of the whole, which, with fig. 2, will furnish a full idea of the history of the attack. The charge employed in each case was 500 lbs. of gun-cotton, equal, as we have said, to 2,000 lbs. of powder.

Trial No. 1, Aug. 6.—The mine was exploded at 100 feet, horizontally, from the starboard side of the vessel. It was at first thought that a considerable effect had been produced. The vessel leaked about the condensers, but it was found that the fault was only in imperfect fixing of the tubes.

No. 2, Aug. 21.—The charge was exploded at 80 feet, horizontally; produced insignificant effect.

No. 3, Sept. 5.—At 60 feet, horizontally, the effect was again inconsiderable.

No. 4, Sept. 26.—At 48 feet from the starboard side considerable effect was produced; the condenser was broken, and other severe injuries were caused, so that it is very doubtful if the vessel could have continued her course.

No. 5, Nov. 12.—To make use of the port side of the vessel the charge was brought over and floated at position shown in

fig. 2. Although only 30 feet horizontally from the ship's side, the effect was so much decreased by the charge being

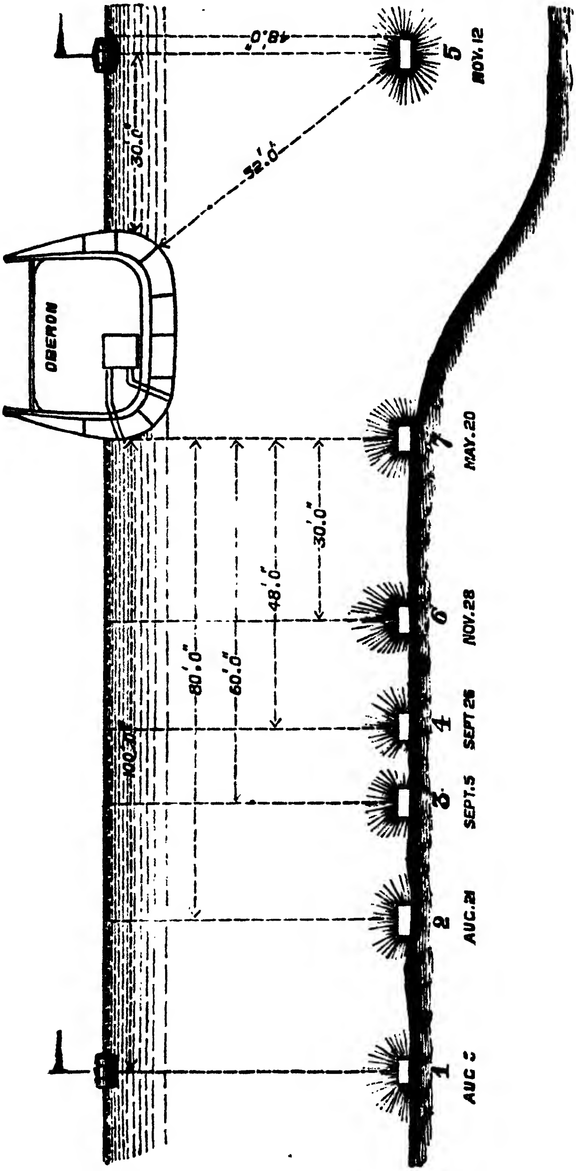


Fig. 2.

floated instead of being on the ground, that an inconsiderable result was produced.

No. 6, Nov. 28.—The charge, now placed at 30 feet from the

starboard side, caused great injury to the ship; thwart plates, casks, and fittings suffered severely, and much leaking was caused.

No. 7, May 20.—The charge was placed vertically beneath the starboard side, and the explosion broke the vessel's back, leaving her a complete wreck, as indeed was to be expected.

The general result of these experiments is rather in favour of the ships than of the mines. It is true that the back of an armour-clad ship might be broken rather more easily than that of the comparatively light *Oberon*; but making all possible allowance, it appears that submarine mines, to effectually close a channel, would have to be so close to each other that an explosion might extend from mine to mine, and the first casualty would open an indefinitely wide gap in the line of defence. In short, the system we proposed to adopt fails, and must be given up. This may be considered a discouraging result to follow on so costly an investigation. It at all events proves the necessity for such experiments, and it is well that they were carried out before the country was involved in more expensive operations. We have now, it may be hoped, time to look for a substitute to a line of large ground mines. We have already mentioned the alternative, namely, a system of small floating charges, which should be fired by contact in close proximity to the ship's side. This change, however, is one involving new difficulties. Tides and currents cause increased complication with this system. Doubtless it may be argued that the action of the small charges, like that of the large ones, depends on the completion of a circuit that may be broken at the will of an operator on shore, so that the channel may be in an instant opened to friendly vessels; nevertheless, the firing will probably have to be effected by gear which is self-acting on the contact of a vessel; and firing at the will of an operator will hardly be attempted. Hence it will be more than ever important to guard lines of submarine mines by powerful batteries, for the process of fishing up charges becomes more easy when the vessel is safe from an operator on shore, and when it is known a charge can only be exploded by actual contact. Moreover, the use of fenders or guards to explode the charges at a distance from the ship's side becomes more feasible.

The next experiments made on submarine defence may be expected to take a new form; 30 to 50 lbs. of cotton is likely to be the maximum charge. The desideratum will be probably a network of such charges floating sufficiently near the surface to catch any vessel at high tide, and yet in place and concealed from view at low tide, with simple galvanic connexions, and not liable to entanglement from currents. This is a problem that may well give Mr. Abel and our officers enough to occupy them for many months to come.

THE NATURAL HISTORY OF THE KANGAROO.

By ST. GEORGE MIVART, F.R.S.

[PLATE CXXVIII.]

THE kangaroos have now become familiar objects to all who visit our Zoological Gardens, or who are familiar with any considerable zoological museum.

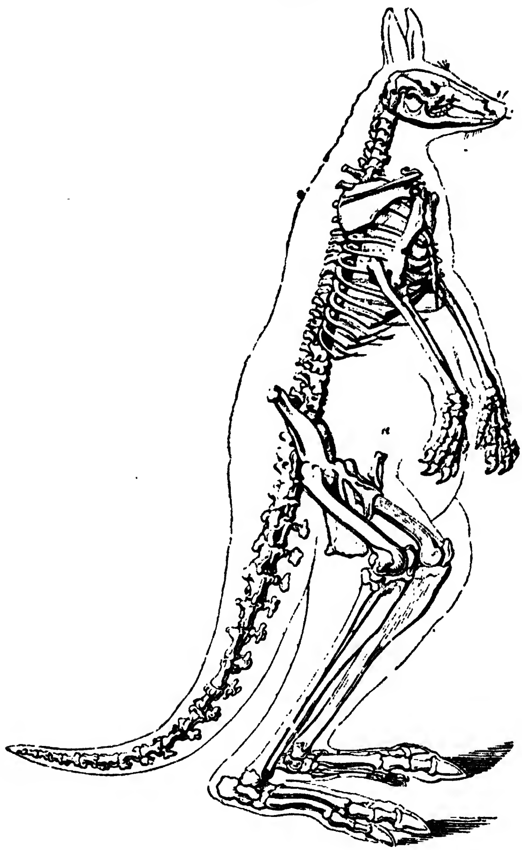
Their general external form, when seen in the attitude they habitually assume when grazing (with their front limbs touching the ground), may have recalled to mind, more or less, the appearance presented by some hornless deer. Their chief mode of locomotion (that jumping action necessitated by the great length of the hind limbs) must be familiar to all who have observed them living, and also, very probably, the singular mode in which the young are carried in a pouch of skin in the front of the belly of the mother.

But "What is a kangaroo?" The question will raise in the minds of those who are not naturalists the image of some familiar circumstances like those just referred to. But such image will afford no real answer to the question. To arrive at *such* an answer it is necessary to estimate correctly in what relation the kangaroo stands to other animals—its place in the scale of animated beings—as also its relations to space and time; that is, its distribution over the earth's surface to-day, in connexion with that of other animals more or less like it, and its relation to the past life of this planet, in connection with similar relations of animals also more or less like it. In other words, to understand what a kangaroo is, we must understand its zoological, geographical, and geological conditions. And my task in this paper is to make these conditions as clear as I can, and so to enable the reader to really answer the question, "What is a kangaroo?"

But before proceeding to these matters, let us look at our kangaroo a little closer, and learn something of its structure, habits, and history, so as to have some clear conceptions of the kangaroo considered by itself, before considering its relations with the universe (animate and inanimate) about it.

The kangaroo (Pl. CXXVIII. fig. 1) is a quadruped, with very long hind limbs and a long and rather thick tail. Its head possesses rather a long muzzle, somewhat like that of a deer, with a pair of rather long ears. Each fore-paw has five toes, furnished with claws. Each hind limb has but two large and

Fig. 1.



Skeleton of Kangaroo (*Macropus*).
a, Marsupial bones.

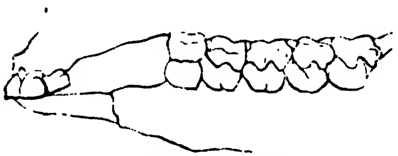
conspicuous toes, the inner one of which is much the larger, and bears a very long and strong claw (Pl. CXXVIII. fig. 2). On the inner side of this is what appears to be a very minute toe, furnished with two small claws. An examination of the bones of the foot shows us, however, that it really consists of two very slender toes united together in a common fold of skin. These toes answer to the second and third toes of our own foot,

and there is no representative of our great toe—not even that part of it which is enclosed in the substance of our foot, called the *inner metatarsal bone.* Two other points are specially noteworthy in the skeleton. The first of these is that the pelvis (or bony girdle to which the hind limbs are articulated, and by which they are connected with the back-bone) has two elongated bones extending upwards from its superior margin in front (fig. 1 *a*). These are called marsupial bones, and lie within the flesh of the front of the animal's belly. The other point is that the lower, hinder portion of each side of the lower jaw (which portion is technically called the "*angle*"), is bent inwards, or "inflected," and not continued directly backwards in the same plane as the rest of the lower jaw.

A certain muscle, called the cremaster muscle, is attached to each marsupial bone, and thence stretches itself over the inner or deep surface of the adjacent mammary gland or "breast," which is situated low down, and not in the breast at all.

The kangaroo's teeth consist of three on each side in the front of the mouth, and one on each side below. These eight teeth are what are called incisors. At the back of the mouth there are five grinding teeth on each side above and five below, and between the upper grinders and incisors another pointed tooth, called a canine, may or may not be interposed. Such a set of teeth is indicated by the following formula, where I stands for incisors, C for canines, and M for grinding-teeth or "molars." The number above each line indicates the teeth of each denomination which exist on one side of the upper jaw, and the lower number those of the lower jaw:—

Fig. 2.



Teeth of Kangaroo (*Macropus*).

$$I\,\frac{3}{1}\;C\,\frac{0}{0}\text{ or }\frac{1}{0}\;M\,\frac{5}{5}=\frac{9}{6}\text{ or }\frac{8}{6}.$$

The total number of incisor teeth of *both* sides of each jaw may therefore be expressed thus: I $\frac{6}{2}$.

Such is the general structure of an adult kangaroo. At birth it is strangely different from what it ultimately becomes.

It is customary to speak of the human infant as exceptionally helpless at birth and after it, but it is at once capable of vigorous sucking, and very early learns to seek the nipple. The great kangaroo, standing some six feet high, is at birth scarcely more than an inch long, with delicate naked skin, and looking like part of an earthworm. Born in such feeble and imperfectly developed condition, the young kangaroo cannot

actively suck. The mother therefore places it upon one of its long and slender nipples (the end of which is somewhat swollen), this nipple entering its mouth, and the little creature remaining attached to it. The mother then, by means of the cremaster muscle (before spoken of), squeezes its own milk gland, and so injects milk into the young, which would thus be infallibly choked but for a noticeable peculiarity of its structure, admirably adapted to the circumstances of the case.

Fig. 3.

1. Dissected Head of young Kangaroo.
a, Elongated larynx. *b*, Cavity of mouth.
2. Nipple of Mother.

In almost all beasts, and in man also, the air-passage or windpipe (which admits air to and from the lungs) opens into the floor of the mouth, behind the tongue and *in front* of the opening of the gullet. Each particle of food, then, as it passes to the gullet, passes over the entrance to the windpipe, but is prevented from falling into it (and so causing death by choking) by the action of a small cartilaginous shield (the *epiglottis*). This shield, which ordinarily stands up in front of the opening into the windpipe, bends back and comes over that opening just when food is passing, and so, at the right moment, almost always prevents food from "going the wrong way." But in the young kangaroo, the milk being introduced, not by any voluntary act of the young kangaroo itself, but by the injecting action of its mother, it is evident that, did such a state of things obtain in it as has been just described, the result would be speedily fatal. Did no special provision exist, the young one must infallibly be choked by the intrusion of milk into the windpipe. But there is a special provision for the young kangaroo; the upper part of the windpipe (or larynx), instead of lying as in us, and as in most beasts, widely separated from the hinder opening of the nostrils, is much raised. It is in fact so elongated in the young kangaroo that it rises right up into the hinder end of the nasal passage, which embraces it. In this way there is free entrance for air from the nostrils into the windpipe by a passage shut off from the cavity of the mouth. All the time the milk can freely pass to the back of the mouth and gullet along each side of this elon-

gated larynx, and thus breathing and milk injection can go on simultaneously, without risk or inconvenience.

The kangaroo browses on the herbage and bushes of more or less open country, and when feeding, commonly applies its front limbs to the ground. It readily, however, raises itself on its hind limbs and strong tail (as on a tripod) when any sound, sight, or smell alarms its natural timidity (Pl. CXXVIII. fig. 1).

Mr. Gould tells us that the natives (where it is found) sometimes hunt these animals by forming a great circle around them, gradually converging upon them, and so frightening them by yells that they become an easy prey to their clubs.

As to its civilized hunters, the same author tells us that kangaroos are hunted by dogs which run entirely by sight, and partake of the nature of the greyhound and deerhound, and, from their great strength and fleetness, are so well adapted for the duties to which they are trained, that the escape of the kangaroo, when it occurs, is owing to peculiar and favourable circumstances; as, for example, the oppressive heat of the day, or the nature of the ground; the former incapacitating the dogs for a severe chase, and the hard ridges, which the kangaroo invariably endeavours to gain, giving him great advantage over his pursuers. On such ground the females in particular will frequently outstrip the fleetest greyhound; while, on the contrary, heavy old males, on soft ground, are easily taken. Many of these fine kangaroo-dogs are kept at the stock stations of the interior, for the sole purpose of running the kangaroo and the emu, the latter being killed solely for the supply of oil which it yields, and the former for mere sport or for food for the dogs. Although I have killed the largest males with a single dog, it is not generally advisable to attempt this, as they possess great power, and frequently rip up the dogs, and sometimes even cut them to the heart with a single stroke of the hind leg. Three or four dogs are more generally laid on; one of superior fleetness to "pull" the kangaroo, while the others rush in upon it and kill it. It sometimes adopts a singular mode of defending itself, by clasping its short, powerful fore limbs around its antagonist, then hopping away with it to the nearest water-hole, and there keeping it beneath the water until drowned.

The kangaroo is said to be able to clear even more than fifteen feet at one bound.

Rapidity of locomotion is especially necessary for a large animal inhabiting a country subject to such severe and widely-extending droughts as is Australia. The herbivorous animals which people the plains of Southern Africa—the antelopes—are also capable of very rapid locomotion. In the antelopes, how-

ever, as in all the hoofed beasts, all the four limbs (front as well as hind) are exclusively used for locomotion. But in kangaroos we have animals requiring to use their front pair of limbs for purposes of more or less delicate manipulation with respect to the economy of the "pouch." Accordingly, for such creatures to be able to inhabit such a country, the hind pair of limbs must by themselves be fitted alone to answer the purpose of both the front and hind limbs of deer and antelopes. It would seem, then, that the peculiar structure of the kangaroo's limbs is of the greatest utility to it; the front pair serving as prehensile manipulating organs, while the hind pair are, by themselves alone, able to carry the animal great distances with rapidity, and so to traverse wide arid plains in pursuit of rare and distant water. The harmony between structure, habit, and climate was long ago pointed out by Professor Owen.

The kangaroo breeds freely in this country, producing one at a birth. We have young ones every year in our Zoological Gardens. A large number of them are reared to maturity, and altogether our kangaroos thrive and do well. One born in our gardens was lately in the habit of still entering the pouch of its mother, although itself bearing a very young one within its own pouch. These animals have been already more or less acclimatized in England. I have myself seen them in grounds at Glastonbury Abbey. Some were so kept in the open by Lord Hill, and some by the Duke of Marlborough. A very fine herd is now at liberty in a park near Tours, in France.

It is a little more than one hundred and five years since the kangaroo was first distinctly seen by English observers.

At the recommendation and request of the Royal Society, Captain (then Lieutenant) Cook set sail in May 1768, in the ship *Endeavour*, on a voyage of exploration, and for the observation of the transit of Venus of the year 1769, which transit the travellers observed, from the Society Islands, on June 3 in that year.

In the spring of the following year the ship started from New Zealand to the eastern coast of New Holland, visiting, amongst other places, a spot which, on account of the number of plants found there by Mr. (afterwards Sir Joseph) Banks, received the name of Botany Bay. Afterwards, when detained in Endeavour River (about 15° S. lat.) by the need of repairing a hole made in the vessel by a rock (part of which, fortunately, itself stuck in the hole it made), Captain Cook tells us that on Friday, June 22, 1770, "Some of the people were sent on the other side of the water, to shoot pigeons for the sick, who at their return reported that they had seen an animal, as large as a greyhound, of a slender make, a mouse-colour, and extremely

swift." On the next day, he tells us: "This day almost everybody had seen the animal which the pigeon-shooters had brought an account of the day before; and one of the seamen, who had been rambling in the woods, told us on his return that he verily believed he had seen the devil. We naturally enquired in what form he had appeared, and his answer was, says John, 'As large as a one-gallon keg, and very like it; he had horns and wings, yet he crept so slowly through the grass that, if I had not been *afeared*, I might have touched him.' This formidable apparition we afterwards, however, discovered to have been a bat (A FLYING FOX)." "Early the next day," Captain Cook continues, "as I was walking in the morning, at a little distance from the ship, I saw myself one of the animals which had been described: it was of a light mouse-colour, and in size and shape very much resembling a greyhound; it had a long tail also, which it carried like a greyhound; and I should have taken it for a wild dog if, instead of running, it had not leapt like a hare or deer." Mr. Banks also had an imperfect view of this animal, and was of opinion that its species was hitherto unknown. The work exhibits an excellent figure of the animal. Again, on Sunday, July 8, being still in Endeavour River, Captain Cook tells us that some of the crew "set out, with the first dawn, in search of game, and in a walk of many miles they saw four animals of the same kind, two of which Mr. Banks's greyhound fairly chased; but they threw him out at a great distance, by leaping over the long, thick grass, which prevented his running. This animal was observed not to run upon four legs, but to bound or leap forward upon two, like the jerboa." Finally, on Saturday, July 14, "Mr. Gore, who went out with his gun, had the good fortune to kill one of these animals which had been so much the subject of our speculation;" adding, "This animal is called by the natives *kanguroo*. The next day (Sunday, July 15) our kanguroo was dressed for dinner, and proved most excellent meat."

Such is the earliest notice of this creature's observation by Englishmen; but Cornelius de Bruins, a Dutch traveller, saw,* as early as 1711, specimens of a species (now named after him, *Macropus Brunii*), which he called *Filander*, and which were kept in captivity in a garden at Batavia. A very fair representation of the animal is given—one showing the aperture of the pouch. This species was, moreover, described both by Pallas† and by Schreber.‡

* See Cornelis de Bruins, *Reizen over Moskovie, door Persie en Indie.* Amsterdam, 1714, p. 374, fig. 213.

† Pallas, *Act. Acad. Sc. Petrop.* 1777. Pt. 2, p. 299, Tab. 4. figs. 4 and 5.

‡ Schreber, *Saugth.* III., p. 551, pl. 153. 1778.

It is not improbable, however, that kangaroos were seen by the earlier explorers of the western coast of Australia; and it may be that it is one of these animals which was referred to by Dampier, when he tells us that on August 12, 1699, "two or three of my seamen saw creatures not unlike wolves, but so lean that they looked like mere skeletons."

Having now learned something of the structure, habits, and history of the kangaroo, we may proceed to consider its zoological, geographical, and geological relations, in order to arrive at the best answer we may to our initial question, "What is a kangaroo?"

First, as to its zoological relations: and here it is necessary to recall to mind certain leading facts of zoological classification, in order that we may be better able to see with what creatures the kangaroo is, in various degrees, allied.

The whole animal population of the globe is spoken of under the fanciful term, the "animal kingdom," in contrast with the world of plants, or "vegetable kingdom."

The animal kingdom is divided into certain great groups, each of which is called a sub-kingdom; and one, the highest of these sub-kingdoms (that to which we ourselves belong), bears the name *vertebrata*, and it includes all beasts, birds, reptiles, and fishes; and the name refers to the series of bone called *vertebræ*, of which the back-bone or spinal column (and all *vertebrata have* a spinal column) is generally made up.

Each sub-kingdom is made up of subordinate groups, termed classes; and thus the vertebrate sub-kingdom is made up of the *class* of beasts or *Mammalia* (so called because they suckle their young), the class of birds, and other classes.

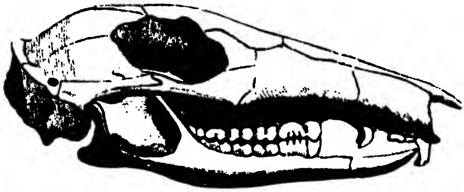
Each class is made up of subordinate groups, termed *orders*; each order is further subdivided into *families*; each family is made up of *genera*; while every genus comprises one, few, or many species.

In considering the zoological relations of the kangaroo, we have then to consider the relations borne by its genera to the other genera of its family, the relations borne by its family to the other families of its order, and finally the relations borne by its order to the other orders of its class (the *Mammalia*)—that class which includes within it all other beasts whatever, and also man.

In the first place, it may be observed, there are many species of kangaroos, arranged in some four genera; but the true kangaroos form a genus *Macropus*, which is very nearly allied to the three other genera. (2) *Dorcopsis*, with a very large first back tooth. (3) The *tree kangaroos* (*Dendrolagus*), which frequent the more horizontal branches of trees, have the fore limbs but little shorter than the hind limbs, and inhabit New

Guinea. (4) The *rat-kangaroos* (*Hypsiprymnus*), which have the first upper grinding tooth large, compressed, and with vertical grooves.

Fig. 4.



Skull of a Rat-kangaroo (*Hypsiprymnus*).

These four genera together constitute the kangaroo's FAMILY, the *Macropodidæ*, the species of which all inhabit Australia and the islands adjacent, but are found nowhere else in the world.

The species agree in having—

(1) The second and third toes slender and united in a common fold of skin.

(2) The hind limbs longer than the fore limbs.

(3) No inner *metatarsal* bone.

(4) All the toes of each fore foot provided with claws.

(5) Total number of incisors only $\frac{6}{2}$.

These five characters are common to the group, and do not coexist in any other animals. They form, therefore, the distinguishing CHARACTERS of the kangaroo's family. This family, *Macropodidæ*, is one of six other families which, together with it, make up that much larger group, the kangaroo's ORDER. As was just said, to understand what a kangaroo is, we must know "what are the relations borne by its *family* to the other families of its order;" and accordingly it is needful for our purpose to take at least a cursory view of those other families.

There is a small animal, called a *bandicoot*, which, in external appearance, differs very plainly from the kangaroo, but resembles it in having the hind limbs longer than the fore limbs, and also in the form of its hind feet, which present a kangaroo structure, but not carried out to such an extreme degree as in the kangaroo, and therefore approximating more to the normal type of foot, there being a rudimentary inner toe and a less preponderant fourth toe; the second and third toes, however, are still very small, and bound together by skin down to the nails. In the fore foot, on the contrary, there is a deficiency, the outer toes being nailless or wanting. The cutting teeth are more numerous, these being I $\frac{10}{8}$.

This little creature is an example of others, forming the family *Peramelidæ*—a family made up of creatures none of

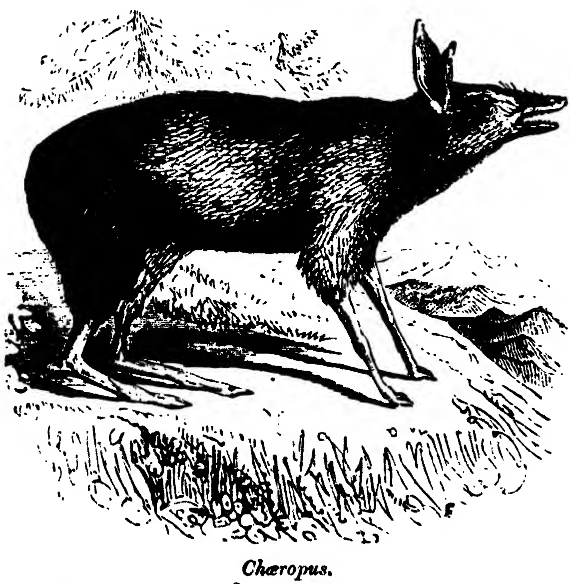
which much exceed the hare in size, and which, instead of feeding on vegetable substances (as do the kangaroos), eat insects,

FIG. 5.

Long-nosed Bandicoot (*Perameles*).

for which food they are well adapted by the sharp points and ridges which may be seen on their back teeth.

FIG. 6.



Chœropus.

One member of this family, *Chœropus*, is very exceptional in the structure of its hind feet, which out-kangaroo the kangaroo

in the minuteness of all the toes but the fourth, upon which alone the creature walks, while its front feet are each reduced to two functional digits.

No other known beast besides walks upon a single toe in each hind foot, save the horse family (horses, asses, and zebras), and they walk upon a different one, namely, that which answers to our middle-toe, while *Chœropus* walks on the next outer one or fourth. No known beast besides *Chœropus* walks upon two toes in each fore foot, save hoofed creatures, such as the ruminants and their allies; but in them it is the third and fourth toes that are used, while in *Chœropus* it is the second and third toes.

FIG. 7.

The Koala (*Phascolarctus*).

Another animal, called a phalanger (of the genus *Phalangista*), is a type of a third family of the kangaroo's order; the *Phalangistidæ*, a family made up of creatures which live in trees and are nocturnal in their habits, feeding upon fruits and leaves. Here we find the limbs of nearly equal length. Once more we have I $\frac{6}{2}$, and we still have the second and third toes united in a common fold of skin; but the innermost toe (that answering to *our* great toe) is not only largely developed, but is like that of the apes, directed outwards, and capable of being opposed to the other toes, as our thumb can be opposed to our fingers.

Some of these creatures have prehensile tails. Others have the skin of the flanks enlarged so as to serve them as a para-

chute in their leaps, whence they are called "flying opossums," just as squirrels, similarly provided, are called "flying" squirrels.

There are two very aberrant members of this family. One, the koala (*Phascolarctus*), called the native bear or native sloth, is devoid of any tail.

The other, *Tarsipes*, but little bigger than a mouse, has a long and pointed muzzle, and its teeth are reduced to minute pointed processes, few in number, $\frac{6-6}{5-5}$, situated far apart in each jaw.

The genus *Cuscus*, closely allied to *Phalangista*, is found in New Guinea and the adjacent islands to Timor (Pl. CXXVIII. fig. 3).

FIG. 8.

The Wombat (*Phascolomys*).

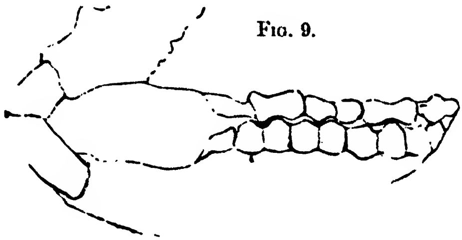
Another animal, the wombat (*Phascolomys*), forms by itself a distinct family, *Phascolomyidæ*. It is a burrowing nocturnal animal, about the size of a badger, with rudimentary tail and peculiar feet and teeth.

We still find the second and third toes bound together, limbs of equal length, and all the five toes of the fore foot with claws

(as in the last family), but the great toe is represented by a small tubercle, while the cutting teeth are $\frac{2}{2}$, growing from persistent pulp through life, as in the rats, squirrels, and guinea-pigs (fig. 9).

We may now pass to a very different family of animals belonging to the kangaroo's order. We pass, namely, to the *Dasyuridæ*, or family of the native-cat, wolf, and devil, so

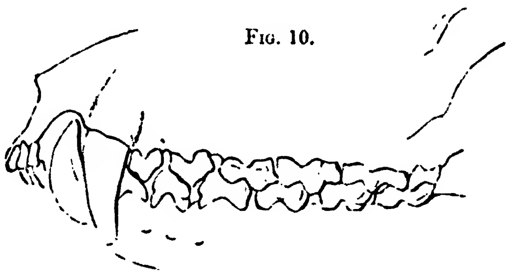
Fig. 9.



Teeth of the Wombat (*Phascolomys*).

named from their predatory or fierce nature. They have well-developed eye-teeth (or canines), and back teeth with sharp cutting blades, or bristling with prickly points. The second and third toes are no longer bound together; and, while there are five toes with claws to each fore foot, the great toe is either absent altogether or small. The cutting teeth are $\frac{8}{6}$, and the tail is long and clothed with hair throughout. Some of these

Fig. 10.



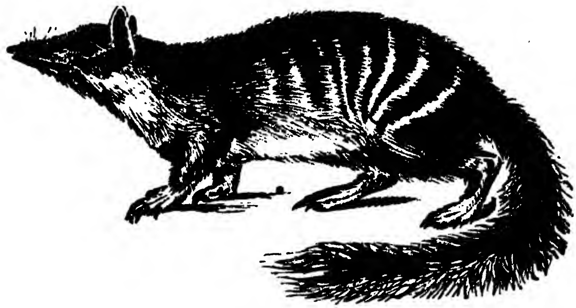
Teeth of *Dasyurus*.

animals are elegantly coloured and marked, and all live on animal food. This form (belonging to the typical genus *Dasyurus*, which gives its name to the family) may be taken as a type; but two others merit notice.

The first of these is *Myrmecobius*, from Western Australia, remarkable for its number of back teeth, $\frac{8-8}{9-9}$, and for certain geographical and zoological relations, to be shortly referred to. With respect to this creature, Mr. Gilbert has told us:—

"I have seen a good deal of this beautiful little animal. It appears very much like a squirrel when running on the ground, which it does in successive leaps, with its tail a little elevated: every now and then raising its body, and resting on its hind feet. When alarmed, it generally takes to a dead tree lying on

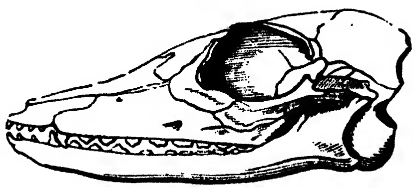
FIG. 11.



Myrmecobius.

the ground, and before entering the hollow invariably raises itself on its hind feet, to ascertain the reality of approaching danger. In this kind of retreat it is easily captured, and when caught is so harmless and tame as scarcely to make any resistance, and never attempts to bite. When it has no chance of escaping from its place of refuge, it utters a sort of half-

FIG. 12.



Skull of *Myrmecobius.*

smothered grunt, apparently produced by a succession of hard breathings."

The other member of the family *Dasyuridæ*, to which I wish to call the reader's attention, is a very different animal from the *Myrmecobius*. I refer to the largest of the predatory members of the kangaroo's order; namely, to the Tasmanian wolf. It is about the size of the animal after which it is named, and it is marked

Fig. 13.

Virginian Opossum (*Didelphys*).

Fig. 14

Didelphys dorsigera.

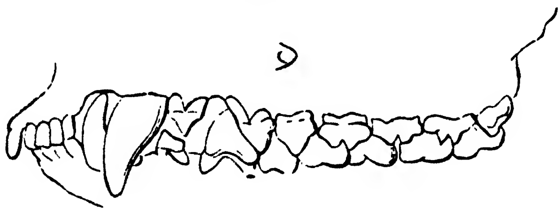
across the loins with tiger-like, black bands (Pl. CXXVIII. fig. 4). It is only found in the island of Tasmania, and will probably very soon become altogether extinct, on account of its destructiveness to the sheep of the colonists. Its teeth have considerable resemblance to those of the dog, and it differs from all other members of the kangaroo's order, in that *mere cartilages* represent those marsupial bones which every other member of the order unquestionably possesses.

The last family of the kangaroo's order consists of the true opossum, which (unlike all the animals we have as yet passed in review) inhabits not the Australian region, but America only.

These creatures vary in size from that of the cat to that of the rat.

They are called *Didelphidæ*, and agree with the *Dasyuridæ* in having well-developed canine teeth and cutting back teeth;

Fig. 15.



Teeth of Opossum (*Didelphys*).

in having the second and third toes free, and five toes to the fore foot. But they differ in that—

(1) Cutting-teeth $\frac{10}{8}$ (more than in any other animal).

(2) A large opposable great-toe.

(3) A tail, naked (like that of the rat) and prehensile.

One of them is aquatic in its habits and web-footed. Such are the very varied forms which compose the six families which together make up the kangaroo's order, and such are the relations borne by the kangaroo's family to the other families of the kangaroo's order.

But to obtain a clear conception of the kangaroo, we must not rest content with a knowledge of its order considered by itself. But we must endeavour to learn the relation of its order to the other orders of that highest class of animals to which the kangaroo and we ourselves both belong, viz. the class *Mammalia*, which class, with the other classes, Birds, Reptiles, and Fishes together, makes up the back-boned or *vertebrate* primary division of the whole animal kingdom.

What, then, is the relation of the kangaroo's order—the Marsupialia—to the other orders of the class Mammalia?

Now these other orders are—

1. The order which contains Man and Apes.
2. That of the Bats.
3. That of the Mole, Shrew, Hedgehog, and their allies—all *insectivorous*.
4. That of the Dog, Cat, Weasel, and Bear—all *carnivorous*.
5. That of the gnawing animals, such as the Rat, Squirrel, Jerboa, and Guinea-pig—all with cutting teeth $\frac{2}{2}$, with permanent pulps. They are called Rodents.
6. The order containing the Sloths.
7. That of the grazing, hoofed quadrupeds—Deer, Antelopes, and their allies.

FIG. 16.

The Yapock (*Chironectes*).

Besides three orders of aquatic beasts (Seals, Whales, and the Manatee order), with which we need not be now further concerned.

Now, in the first place, very noticeable is the much greater diversity of tructure found in the kangaroo's order than in any other order of mammals. While each of the *latter* are of one predominate type of structure and habit, we have found in the marsupials the greatest diversity in both.

Some marsupials are, we have seen, arboreal, some are burrowing, some flit through the air, while others range over and graze upon grassy plains. Some feed on vegetable food only, others are as exclusively insectivorous or carnivorous,

and their teeth vary much in number and structure. Certain of my readers may wonder that such diverse forms should be thus grouped together, apart from the other mammals. At first sight it might seem more natural to place together *flying opossums* with *flying squirrels*; the *native sloth* with the *true sloth*; the *dog* and *cat-like opossums* with the *true dogs* and *cats*; and, lastly, the *insectivorous marsupials* with the *other insectivora*.

As to the kangaroos themselves, they might be considered as approximating in one respect to the Ruminants, in another to the Rodents.

We have seen that even in Captain Cook's time its resemblance to the jerboa forced itself into notice. And, indeed, in this jerboa (and its first cousin, the *alactaga*) we have the same or even a relatively greater length of hind limb and tail, and we have the same jumping mode of progression.

Again, in the little jumping insectivorous mammal, the shrew (*Macroscelides*), we meet with excessively long hind limbs and a jumping habit. More than this: if we examine its teeth, we find both in the upper cutting teeth and in the back teeth great resemblance to those of the kangaroo. And yet there is no real affinity between the kangaroo and such creatures, any more than there is between a non-marsupial truly carnivorous beast and a marsupial carnivore. Indeed, both myself and my readers are far more like the Jerboa or Weasel than either of the latter are like to any marsupial animal.

The fact is, that all these so varied marsupial forms of life possess in common certain highly important characters, by which they differ from all other mammals. These characters, however, mainly relate to the structure of their reproductive organs, and could not be here detailed without a long preliminary anatomical explanation: but as to the great importance of these characters, naturalists are agreed.

Amongst the characters which serve to distinguish the marsupials, there are two to which I have already called attention in describing the kangaroo; namely, the marsupial bones and the inflected angle of the lower jaw.

Every mammal which has marsupial bones has the angle of its jaw inflected, or else has no angle to its jaw at all; while every animal which has both marsupial bones and an inflected jaw-angle possesses also those special characters of the reproductive system which distinguish the marsupials from all other mammals.

Thus it is clear we have at least two great groups of mammals. One of them—the non-marsupials—contains Man; the Apes; Bats; Hedgehog-like Beasts (Shrews, Moles, &c.); Cats, Dogs, Bears, &c.; Hoofed Beasts; Edentates; Rodents, and also

the Aquatic Mammals. And this great group, containing so many orders, is named MONADELPHIA.

The other great groups consist of all the marsupials, and no others. It consists, therefore, of the single order, *Marsupialia*, and is called DIDELPHIA.

Another group of mammals is made up of two genera only—the Duck-billed Platypus or *Ornithorhyncus* and the *Echidna*, two most interesting forms but which cannot be further noticed here. They form, by themselves, a theme amply sufficient for an article, or even half-a-dozen articles.

As to its zoological relations, then, we may say that *the kangaroo is a peculiarly modified form of a most varied order of mammals (the* MARSUPIALS*), which differ from all ordinary beasts* (and at the same time differ from man) *by very important anatomical and physiological characters, the sign of the presence of which is the coexistence of marsupial bones with an inflected angle of the lower jaw.*

We may now proceed to the next subject of enquiry, and consider the space relations (that is, the geographical distribution) of the kangaroo, its family, and order. I have already incidentally mentioned some countries where marsupials are found, but all of these were more or less remote. To find living, in a state of nature, any member of the kangaroo's order, we must at least cross the Atlantic.

When America was discovered by the Spaniards, amongst the animals found there, and afterwards brought over to Europe, were *opossums*, properly so called—marsupials, of the family *Didelphidæ*, which extend over the American continent, from the United States to the far South. These creatures were the first to make known to Europeans* that habit of sheltering the young in a pouch which exists in the kangaroo, and which habit has given the name *Marsupialia* to the whole order. But though this habit was duly noted, it is not strange that (being the only pouched forms then known) the value of the peculiarity should have been under-estimated. It is not strange that they should have been regarded as merely a new kind of ordinary flesh-eating beasts, since in the more obvious characters of teeth and general form they largely resembled such beasts. Accordingly even the great Cuvier, in the first edition of his "Règne Animal," made them a mere subdivision of his great order of flesh-eating mammals.

But to find any other member of the kangaroo's order

* The following are some amongst the earlier notices of these animals:—"Historie d'un Voyage fait en la terre du Brésil," par Jean de Léry; Paris, 1578, p. 156. Hernande's "Hist. Mex.," p. 330. 1626. "Historie Naturelle des Antilles;" Rotterdam, 1658. "Anatomy of an Opossum," Tyson, Phil. Trans., 1698.

(besides the *Didelphidæ*), in a state of nature, we must go much further than merely across the Atlantic; namely, to Australia or the islands adjacent to it, including that enormous and unexplored island New Guinea, which has recently attracted public attention through the published travels of a modern Baron Munchausen.

To return, however, to our subject. To find marsupials at all, we have, as we have seen, to go to the New World. To find nearer allies of the kangaroo, we must go to the *newest* world, Australia; *newest* because, if America merited the title of *new* from its new natural productions as well as its new discovery, Australia may well claim the superlative epithet on both accounts. We have found an indication, in the name Botany Bay, of the interest excited in the mind of Sir Joseph Banks by the new plants as well as by the new animals of Australia. And, indeed, its plants and animals do differ far more from those of the New World (America) than do those of America from those of the Old World.

Marsupials, in fact, are separated off from the rest of their class—from the great bulk of mammals—the *Monodelphia*—no less by their geographical limits than by their peculiarities of anatomical structure.

And these geographical limits are at the same time the limits of many groups of animals and plants, so that we have an animal population (or fauna) and a vegetable population (or flora) which is characteristic of what is called the Australian region—the Australian *region*, because the Australian forms of life are spread not only over Australia and Tasmania, but over New Guinea and the Moluccas, extending as far north-west as the island of *Lumbock*, while marsupials themselves extend to *Timor*.

In India, the Malay peninsula, and the great islands of the Indian Archipelago, we have another and a very different fauna and flora—that, namely, of the Indian region, and Indian forms of life extend downwards south-east as far as the island of Bali. Now Bali is separated from Lumbock by a strait of but fifteen miles in width. But that little channel is the boundary line between these two great regions—the Australian and the Indian. The great Indian fauna advances to its western margin, while the Australian fauna stops short at its eastern margin.

The zoological line of demarcation which passes through these straits is called "Wallace's line," because its discovery is due to the labours of that illustrious naturalist, that courageous, persevering explorer, and most trustworthy observer, Alfred Wallace, a perusal of whose works I cordially recommend to my readers, since the charm of their style is as remarkable as is the sterling value of their contents. Mr.

Wallace pointed out that not only as regards beasts (with which we are concerned to-day), but that also as regards birds, these regions are sharply limited. "Australia has," he says, "no woodpeckers, no pheasants—families which exist in every other part of the world; but instead of them it has the mound-making brush-turkeys, the honeysuckers, the cockatoos, and the brush-tongued lories, which are found nowhere else upon the globe."

All these striking peculiarities are found also in those islands which form the Australian division of the Archipelago, while in those islands which belong to its Indian division these Australian birds have no place.

On passing from the island of Bali to that of Lumbock, we cross the division between the two. "In Bali," he tells us, "we have barbets, fruit-thrushes, and woodpeckers, while in Lumbock these are seen no more; but we have abundance of cockatoos, honeysuckers, and brush-turkeys, which are equally unknown in Bali, or any island further west."

As to our second point, then—the geographical relations of the kangaroo—we may say that the *kangaroo is one of an order of animals confined to the Australian region and America, the great bulk of which order, including the kangaroo's own family,* MACROPODIDÆ, *is strictly confined to the Australian region.* We may further add, that in the Australian region ordinary beasts (*Monodelphia*) are entirely absent, save some bats and a rat or two, and the wild dog or dingo, which was probably introduced there by man himself.

There only remains, then, for us to enquire, lastly, what relations with past time may be found to exist on the part of the kangaroo's order or of the kangaroo itself. Now, in fact, these relations are of considerable interest. I have spoken of Australia as, what in one sense it certainly is, the *newest world*, and yet *the oldest world* would, in truth, be an apter title for the Australian region.

In these days we hear much of "survivals," as the two buttons behind our frock-coats are "survivals" of the extinct sword-belt they once supported, and the "Oh, yes! oh, yes! oh, yes!" of the town-crier is a "survival" of the former legal and courtly predominance of the French language amongst us. Well, in Australia we have to-day a magnificent case of zoological survival on the largest scale. There, as has already been said, we find living the little *Myrmecobius*, which represents before our eyes a creature living in the flesh to-day, which is like other creatures which once lived here in England, and which have left their relics in the Stonesfield oolite, the deposition of which is separated from our own age by an abyss of past time not to be expressed by thousands of years, but only to be

indicated in geological language as the Mesozoic period—the middle of the secondary rocks.

But Australia presents us with a yet more interesting case of "survival." Certain fish-teeth had from time to time been found in deposits of oolitic and triassic date, and the unknown creature to which they once belonged had received the name of *Ceratodus.* Only five years ago this animal, supposed to have been extinct for untold ages, was found still living in Queensland, where it goes by the name of "flat head." It is a fish of somewhat amphibious habits, as at night it leaves the brackish streams it inhabits, and wanders amongst the reeds and rushes of the adjacent flats. The anatomy of this animal has been carefully described for us by Dr. Günther.

We have, then, in Australia what may be termed a triassic land, still showing us in life to-day the more or less modified representations of forms which elsewhere have long since passed away from amongst us, leaving but rare and scattered fragments —relics "sealed within the iron hills."

No member of the Australian families of the kangaroo's order has left its relics in European strata more recent than the secondary rocks. But the American family, *Didelphidæ,* is represented in the earliest tertiary period by the remains of an American form (a true opossum) having been found by Cuvier in the quarries of Montmartre. He first discovered a lower jaw, and, from its inflected angle, concluded that it belonged to a marsupial animal, and that therefore marsupial bones were hidden in the matrix. Accordingly he predicted that such bones would be found; and, proceeding to remove the enveloping deposit with the greatest care, he laid bare before the admiring eyes of the bystanders the proof of the correctness of his prediction. It is noteworthy, however, that had this fossil been that of an animal like the Tasmanian wolf, he would have been disappointed, as, though marsupial, it has, as has been already said, not marsupial *bones,* but *cartilages.*

But relics of creatures more closely allied to the kangaroo existed in times ancient historically, though, geologically speaking, very recent. Just as in the recent deposits of South America we find the bones of huge beasts, first cousins to the sloths and armadilloes which live there now, so in Australia there lived beasts having the more essential structural characters of the kangaroo, yet of the bulk of the rhinoceros. Their bones and teeth have been found in the tertiary deposits of Australia. They have been described by Professor Owen, and are now to be seen preserved in the British Museum and that of the Royal College of Surgeons. It may be that other fossil forms of the middle mesozioc or even of triassic times may, as some believe, have belonged to creatures of the kangaroo's family;

but at least there is no doubt that such existed in times of post-tertiary date.

As to our third point—the geological relations of the kangaroo—we may say, then, that "*the kangaroo is one of an order of animals which ranged over the northern hemisphere in triassic and oolitic times, one exceptional family lingering in Europe to the Eocene period, and in America to the present day. That the kangaroo itself is a form certainly become fossil in its own region, where, in times geologically recent, creatures allied to it, but of vastly greater bulk, frequented the Australian plains.*"

We may now, then, proceed to answer finally the question, "*What is a kangaroo?*" We may do so because the meaning of the technical terms in which the answer must necessarily be expressed (if not of undue length) have been now explained, as far as space has allowed.

We may say, then, that "*the kangaroo is a didelphous (or marsupial) mammal, of the family* MACROPODIDÆ; *an inhabitant of the Australian region, and connected, as respects its order, with triassic times, and possibly even as regards its family also, though certainly (as regards the latter) with the time of the post-tertiary geological deposits.*"

We have seen what are didelphous and what are menadelphous mammals; what are the respective values of the terms "order," "family," and "genus," and also in what respect the kangaroo differs from the other families of the marsupial order. We have also become acquainted with the distribution of organic life now and with the inter-relations of different geological strata, as far as those phenomena of space and of time concern our immediate subject.

By becoming acquainted with these matters, and by no other way, is it possible to give an intelligent answer to the question, "*What is a kangaroo?*"

DESCRIPTION OF PLATE CXXVIII.

FIG. 1. *Macropus Parryi.* (From the Transactions of the Zoological Society, vol. i. p. 300.)

„ 2. Sole of Right Foot of Kangaroo.

„ 3. *Cuscus Orientalis.* (From the Proceedings of the Zoological Society for 1858, Pl. LXI.)

„ 4. *Thylacinus Cynocephalus.* (From the Proceedings of the Zoological Society for 1850, Pl. XVIII.)

RECENT DISCOVERIES IN PHOTOGRAPHY.

By J. TRAILL TAYLOR.

AMONG recent discoveries in photography there are two which appear to exercise an important influence upon the future practice of the art-science. One of these refers to the production of negatives, the other to the printing of positives, or proofs upon paper.

As hitherto practised, the production of a negative involves several manipulations of a somewhat messy nature. The argentic halogens, iodide and bromide of silver, which constitute the sensitive body in the collodion film, have been formed by double decomposition, a collodion containing a haloid salt being immersed in a bath of nitrate of silver, by which iodide of silver is precipitated in the film, together with the nitrate of the base of the salt, which, being soluble, remains in the bath to contaminate the silver. If the plate is to be dried and stored away for future use, it is now subjected to a series of washings to eliminate the soluble salts, after which it is "preserved" by the application of an organic solution such as gelatine, tannin, gum, and other bodies.

With a view to simplify these complex processes it had long been considered desirable that the haloid salts of silver should be mixed with the collodion, so as to ensure by a single operation the coating of the plate with a sensitive layer. But it was found that the large atoms of iodide of silver would not emulsify with collodion; and all attempts at producing a sensitive collodion failed, until about ten years ago, when two Liverpool amateurs, Sayce and Bolton, solved the problem of producing a sensitive collodion emulsion by discarding entirely the iodide of silver, and substituting for it bromide of silver. The best conditions under which this bromide emulsifies has for several years formed a theme for the investigations of scientific photographers, and these researches have greatly conduced to the high state in which the art exists at the present time. Such is the state of perfection to which the system of preparing sensitive

plates has been brought during the past year, that all baths, washings, preservatives, and organifiers may now be entirely dispensed with, the sensitive emulsion being so composed as to contain within itself everything that conduces to the rendering the sensitive film complete.

A practical difficulty that long existed in the preparation of a sensitive emulsion lay in hitting so exactly the combining equivalents of the salts used in sensitising the collodion as to leave neither of them in excess. The bromide of silver being formed in the collodion by the decomposition of nitrate of silver and a soluble bromide, there was a difficulty, well-nigh amounting to impossibility, in so combining them as not to allow either to predominate. To make a combination in water is easy; but not so is it in a thick, viscid liquid like collodion. If the silver be left in excess, fogging of the negative is certain to follow, unless a restrainer like mineral acid be added; if, on the other hand, the bromide preponderate, the plate is insensitive in proportion to that excess; and hence for some time it was customary to have a much larger proportion of bromide present than was necessary, and after coating a plate with an emulsion of that kind to confer sensitiveness upon it by washing with water, so as to effect the removal of the free bromide which acted so powerfully as a retarder. A further necessity for having the free bromide removed was found in the fact that when an image is impressed upon a film containing it, unless that latent image be quickly developed, it is rapidly destroyed by the soluble bromide.

It has already been said that a result of the decomposition arising from immersing a salted collodion plate in a nitrate of silver bath is not only the formation of bromide of silver, but also of the nitrate of the base of the haloid salt. The presence of this nitrate in a wet process is of minor consequence, but far different is it when it exists in a collodion film that is to be dried; for on crystallising out, as it must necessarily do if present in a moderately large quantity, it disintegrates the film; and even if quite innocuous in a chemical sense, its presence is fatal in a physical point of view.

The maleficent influence of the crystallisable salt resulting from the decomposition had previously been noted by Mr. J. King, of the Bombay Civil Service, during a brief visit to this country; and when making experiments with gelatine instead of collodion as a vehicle for the sensitive bromide, he, by a happy application of the principle of dialysis, succeeded in effectually removing every crystallisable compound, as will be presently shown. The method subsequently adopted by Mr. Bolton in effecting a similar removal on behalf of collodion was very complete, inasmuch as he not only eliminated the crystallisable

salt but also added the requisite organifier or preservative body, by which the pores of the film are kept sufficiently open to be permeated by the developing solutions afterwards to be applied.

The simplicity of the method adopted is great, its efficiency is obvious. A collodio-bromide emulsion that has been so nearly adjusted in relation to the predominance of one salt over another as to be in moderately good working order is poured into a large flat dish. After a few hours, when the thick film has become set, a small quantity of distilled water is poured upon it and the film divided into squares by means of a paper-knife or silver fruit-knife. By thus breaking up the film and subjecting it to a few changes of water all the soluble matter is entirely removed, this removal having been facilitated by the addition of a little glycerine to the emulsion before it was poured out to set. The function of the glycerine is mechanical, not chemical. When the whole of the crystallisable salts are removed the film is dried, and is either ready for being re-dissolved immediately, or for storing away for future use. There appears to be no limit to its keeping powers, provided it be kept in a place from which light is excluded. To render this dried pellicle ready for use it is only necessary that it be dissolved in a mixture of equal parts of ether and alcohol, adding to it a little of an alcoholic solution of tannin and a similar solution of soap.

To use a collodion prepared in this or any similar way all that is necessary is to pour a little of it on the glass plate on which the negative is to be taken, allow it to dry, and either expose it in the camera without further preparation or place the plate away until it is convenient to use it. In this way it will be seen that photography is now reduced to a state of great simplicity, so far, at any rate, as the preparation of the plates is concerned.

Armed with a bottle of this sensitive emulsion, a photographer or tourist may now visit any country with the certainty that, wherever he can procure glass plates cut to such sizes as he may require, there can he have sensitive plates—plates, too, absolutely identical with each other in respect of sensitiveness—uniformity being a necessary consequence of the method by which they are prepared. To one accustomed to the preparation of plates by the usual bath method, with the subsequent washings and preservatives, it is very difficult at first to realise the extreme simplicity of the "washed emulsion process." In the simple act of pouring the collodion from a bottle on to a glass plate every operation is now included. The result is a plate capable of yielding a high-class negative, and possessing quite as great a degree of sensitiveness as dried collodion plates prepared by any other method.

It might at first sight appear as if the atoms of bromide of silver when used in the emulsified form would be coarse and granular, producing a corresponding granularity in the finished negative when compared with a film in which the decomposition was made. But it is a singular fact that when a negative of the former kind is subjected to microscopic examination the atoms of metallic silver of which the image is composed are extremely fine—so fine, indeed, as, with a power of two-thirds of an inch, to show like a stain. When a negative taken in the usual way—that is, with a silver bath and iron development —is examined under the same power, it appears exceedingly coarse, the atoms of reduced silver being very large.

But it is not necessary that the sensitive preparation be kept in a fluid form. We have just said that there appears to be no limit to the keeping properties of the desiccated pellicle, provided it be kept away from the light. A most useful and practical application of this fact is, that a traveller can take with him to any distant country a small packet of this pellicle, either in a pellicular or a pulverulent form; and in both of these states the preparation is now commercially obtainable. The advantage of this to the tourist cannot be over-estimated. When the photographic visitor to the Continent takes with him a supply of dried plates he runs a risk of having them spoilt by the examination, in daylight, of the Custom House officials; when he takes with him only a bottle of emulsion this danger is reduced to a minimum, especially if the bottle be actinically opaque. But by taking with him, instead of these, a supply of the sensitive collodion in the form of a coarse powder, he secures the maximum of convenience without any risk whatever. To prepare a solution for use a certain proportion of this powder is added to a mixture of ether and alcohol, in which it is dissolved; and thus is made a collodion fit for immediate use.

To prepare this sensitive collodion, dissolve a hundred and thirty-five grains of pyroxyline in fifteen ounces of a mixture of ether and alcohol. There must be ten ounces of ether to five of alcohol, but both of these may be the most common methylated kind. In this is dissolved a hundred and eighty grains of anhydrous bromide of cadmium. To this is then added a solution of three hundred grains of nitrate of silver in five ounces of methylated spirits, the solution being aided by heat and the addition of a little water. It is poured in the collodion gradually, with intermediate shaking, and is then allowed to stand for several hours; after which an excess of bromide is added, consisting of seventy grains dissolved in an ounce of methylated alcohol. After being well mixed and allowed to stand for two or three hours an ounce of glycerine is added, and the whole is poured out in a flat dish, washed and dried. It is then cut into

shreds, reduced to powder, or packed away in any other suitable form, ready for being dissolved when wanted.

It is necessary, in order to obtain the best results, that organic matter be added to the emulsion. The kind recommended by Mr. Bolton is composed of forty grains of tannin dissolved in an ounce of an alcoholic saturated solution of soap, twenty minims of this being added to each ounce of emulsion.

The development of the image is best effected in the following manner:—First wet the surface of the plate by pouring over it methylated alcohol, followed by a rinsing with water. Next apply a four-grain solution of pyrogallic acid, which in the course of about a minute generally brings out a very feeble picture; but at the end of this time, whether a picture be visible or not, pour off the developing solution into a vessel containing a few drops of greatly diluted ammonia (one drachm of ammonia to thirteen drachms of water), together with an equal proportion of a ten-grain solution of bromide of cadmium, and apply again to the plate. This will immediately bring out the image in great vigour, the silver of which the picture is formed being obtained at the expense of the bromide, which is reduced.

At this stage the negative image may be converted into a positive. To effect this it is only necessary to apply diluted nitric acid, which dissolves metallic silver, but leaves the bromide of that metal unaltered. Now, as the opaque portions are composed of reduced silver, such parts are consequently denuded of bromide; hence the solvent action of the acid renders the glass more or less transparent in the exact ratio of its previous opacity. This principle is now being successfully applied in the production of transparencies and enlargements by a single operation.

But simultaneous with, or rather previous to the successful working out of the interesting photographic process just described, Dr. R. L. Maddox had conceived the idea of emulsifying gelatine, instead of collodion, with bromide of silver. Having worked out his idea to a practical issue with that intelligent assiduity so characteristic of this gentleman, he had to withdraw from this pursuit, which, however, was taken up by others. It was soon found that when the gelatine was well charged with bromide of silver it was more sensitive than collodion; but the crystallisable nitrates resulting from the decomposition by which was formed the bromide of silver precluded the possibility of fully utilising this quality, for the film was unable to retain these nitrates without undergoing disintegration. Mr. King, to whom allusion has been made, effected the removal of the soluble salts by the well-known principle of dialysis. The gelatine having been liquefied, bromide of potas-

sium and nitrate of silver, each previously dissolved in water, are added, and after a sufficient time is allowed to enable them to re-act upon each other the solution is poured into a dialyser, which is placed in a vessel of warm water. In a few hours the whole of the crystalline salts will be found to have passed through the septum of the dialyser. Here, then, is a means by which a gelatine film may be loaded with bromide of silver, free both from excess of either of the two salts employed to effect the decomposition, as well as from the nitrate of potash which results from that decomposition.

Only a short time has elapsed since the foregoing discovery, but during that time great progress has been made. Mr. R. Kennett has further simplified the preparation of the gelatino-pellicle by making itself the septum, and doing away with a separate dialyser. He mixes with the gelatine the necessary salts, pours the whole out into a flat dish, and when the gelatine has set, but not become desiccated, he merely places it in a vessel of cold water, by which everything of a crystallisable nature is removed; after which the sensitive colloidal body is dried, cut up into shreds, placed in opaque packets, and may be transported to any part of the world, ready to be converted into a highly sensitive emulsion by the addition of warm water.

A singular fact, for the elucidation of which no tenable hypothesis has yet been brought forward, is that a gelatino-bromide emulsion film is extremely sensitive, much more so than one of collodion. The quality of negative obtained on plates so prepared is most excellent, while the atoms of silver of which the image is composed, when examined under the microscope, partake even still more of the nature of a stain than a collodion emulsion negative. This process is still in its infancy, but from its having been brought to such a state of perfection during the brief period of its existence it is safe to predicate that further improvements will rapidly be effected. The way by which we successfully develope gelatine plates is similar to that already described for collodion plates, omitting the application of alcohol and substituting for it a rinsing with water.

Although gelatine at present possesses such a marked advantage over collodion in respect of sensitiveness, it is difficult to work with it in hot weather; and the emulsion must be used soon after it is made, otherwise putrefaction will set in; and it is unfortunate that the addition of any of those antiseptics which prevent putrefaction affects the excellence of the emulsion. Salicylic acid is being tried for this purpose as well as some preparations of camphor; but while we hope much from their agency, our experiments with them are not sufficiently advanced to warrant the results being recorded in this article.

In the meantime Mr. Stillman, who has done much for dried collodio-emulsions, and who has succeeded in making one of excellence and stability, is engaged in trying to solve the problem of conferring as much sensitiveness on the collodion pellicle as that at present possessed by gelatine. That he will succeed we have every reason to believe, judging by what we have seen in course of our experiments with him. A revolution in the practice of negative photography is rapidly being effected; when a dried collodion emulsion shall have been obtained that will possess the sensitiveness of gelatine the revolution will be complete.

Not alone in the production of negatives have discoveries been recently made. It has been a standing disgrace to photography that its prints faded; their permanence could never be relied upon. Hence the endeavours to have silver printing supplanted by carbon or any other reliable substance.

Starting with the idea of printing photographs in the most stable metals known, such as platinum or iridium, Mr. William Willis, jun., recently sought to find a good reducer of these metals, and spent some time in making experiments with ferrous oxalate, a beautiful lemon-yellow powder, known to be insoluble in water and most other menstrua. Working away for a time without any satisfactory result, he eventually discovered that a solution of it in the neutral oxalate of potash instantly precipitated the metal from the ordinary chloride of platinum; in other words, he found that a solution of ferrous oxalate in potassic oxalate reduced salts of platinum to the metallic condition. Now, as fer*rous* oxalate can be produced by the action of light upon fer*ric* oxalate, it follows that if paper which has received a wash of chloride of platinum and ferric oxalate be exposed under a negative in the printing frame, and then receive a wash of potassic oxalate, the metal will be reduced in proportion to the action of the light.

When this printing process, the principle of which we have thus described, is carried out in actual practice, a picture of a fine quality is obtained by an exposure to light of about one-fifth of that required for ordinary silver printing; that, at any rate, is the estimate we made when witnessing the process worked. When the pictures are taken from the printing frame they are feebly although distinctly visible, although up to this stage the platinum has not taken any part in the performance. The visible picture is composed of ferrous oxalate, and it would have been equally visible had no platinum been present. The picture is now drawn over a solution of potassic oxalate, and instantly, as the result of this contact, the image becomes strong and rich, of a warm velvety-black tone.

As far as mere permanence is concerned the picture is now

finished—boiling nitric acid would have no effect upon it. But it must be remembered that the paper was sensitised by ferric oxalate, and it is desirable that it be removed. To effect this the print is immersed in a weak solution of oxalic acid, by which the whites are rendered very pure. Rinsing in plain water completes the operation. There is a great charm about these pictures, which are made on plain paper, the tones being like that of a warm engraving. Added to their beauty and the rapidity of their production, they resist all the usual destructive tests.

The developing action of the potassic oxalate will readily be comprehended from the following considerations:—Bearing in mind the axiom that no chemical action can take place unless one of the substances be in a liquid form, observe that when the picture is removed from the printing frame the two substances—the ferrous oxalate and the platinum salt—are both solid, and hence the former body has not had an opportunity of acting upon the latter; both are side by side, and in the most favourable position for one to act upon the other, but it is held in check. The question now arises, What will release it, so that it may reduce the platinum, so conveniently situated for this purpose? It is not soluble in water, but is so in a solution of potassic oxalate. No sooner, therefore, is the picture placed in contact with such a fluid than the exposed parts—consisting of ferrous oxalate — are liquefied and instantaneously exert their reducing action on the neighbouring particles of platinum, which thus are made to form the picture.

REVIEWS.

INSECTIVOROUS PLANTS.*

HOW often have we not heard the question asked by officers of the Army and Navy who have been abroad, What is to be done in a place like India? what resources lie open to a man but hunting, shooting, and flirtation? And what a splendid reply is given by the author of the work on Insectivorous Plants which is now before the world. It is to an ordinary person perfectly astounding what a naturalist of Mr. Darwin's turn of mind can see in objects which have been under the eyes of all, and yet have not till now been properly observed. And the present volume is literally a perfect storehouse of observations which have been conducted by Mr. Darwin, and by certain foreigners who have been even earlier in the field than the renowned English biologist. It will, doubtless, appear strange to the person who is not well versed in modern natural history, that the present work has to do exclusively with the different modes in which certain plants capture, kill, and devour animals; yet assuredly such is the nature of the book's contents. Mr. Darwin covers more than 450 pages by his graphic accounts of the different plants he has watched, of their several modes of capturing their prey, and of the effects of different inorganic and organic substances on their power of digestibility. And of his mode of conducting his experiments, and his careful method of carrying on his observations, it is impossible to speak (as, of course, those who are familiar with Mr. Darwin's writings would have anticipated) in too impressive a manner. He has given us the history of more than twenty different plants, some of them, as *Drosera*, at immense length, and with a vast number of original observations, and others which were had with great difficulty from abroad, and which only allowed of a limited number of experiments, less abundantly experimented on, but not on that account with less accuracy of observation. In every case we note—what we have ever had to observe in writing of Mr. Darwin—that tendency to give the utmost credit to his fellow-labourers, even when the observations made by them do not in any way agree with his own.

Mr. Darwin appears to be the first who has accurately recorded those various changes which certain cells appear to undergo even in a compara-

* "Insectivorous Plants." By Charles Darwin, M.A., F.R.S., &c. With Illustrations. London: John Murray, 1875.

tively brief space of time. His diagrammatic sketches of a cell, which show the several changes it has undergone in the course of about sixteen minutes, are full of interest, and they will at once recall to the mind of the student of human microscopic anatomy the sort of thing seen when a fresh piece of certain mucous membranes is submitted to examination. We think, in regard to those observations, that what the writer remarks is extremely probable—for, indeed, we have ourselves witnessed it when employing improved illuminators—viz. that in some of the specimens, in which apparently two distinct cells existed, there really was a connecting cord, which was "drowned" by the method of throwing the light on the object. He says, p. 41: "At first there was at the base of the cell a little mass on a short footstalk, and a larger mass near the upper end, and these seemed quite separate. Nevertheless, they may have been connected by a fine and invisible thread of protoplasm, for on two other occasions, whilst one mass was rapidly increasing and another in the same cell rapidly decreasing, I was able, by varying the light and using a high power, to detect a connecting thread of extreme tenuity, which evidently served as the channel of communication between the two."

Of the many experiments the author has made with reference to the digestible power of certain plants, some of the most interesting are those he conducted on the *Drosera rotundifolia*. These showed that raw flesh, when placed upon the leaf, was completely digested in a comparatively short space of time. But one would have thought that bone was entirely beyond the power of the plant. It does not appear so from the following account which Mr. Darwin has given:—"Dr. Burdon Sanderson suggested to me that the failure of *Drosera* to digest the fibrous basis of bone might be due to the acid being consumed in the decomposition of the earthy salts, so that there was none left for the work of digestion. Accordingly, my son thoroughly decalcified the bone of a sheep with weak hydrochloric acid, and seven minute fragments of the fibrous bases were placed on so many leaves, four of the fragments being first damped with saliva to aid prompt inflection. All seven leaves became inflected, but only very moderately, in the course of a day. They quickly began to re-expand, five of them on the second day, and the other two on the third day. On all seven leaves the fibrous tissue was converted into perfectly transparent, viscid, more or less lignified little masses." Thus we see that even decalcified bone was nearly completely dissolved by the plant, although evidence of absorption was not as clearly shown. Among other curious experiments conducted on the *Drosera* was one of some importance, as it shows what a difference may exist between the action of a poison on animals and plants. It was the trial of cobra poison, which, while it is most deadly in its action on animal life, does not appear to have any influence on the vitality of the plant. The author says that "from these facts it is manifest that poison of the cobra, though so deadly to animals, is not at all poisonous to *Drosera*, yet it causes strong and rapid inflection of the tentacles, and soon discharges all colour from the glands." Indeed, he seems to think that in some way or other it acts as a stimulant to the protoplasm of the plant.

Another point which Mr. Darwin has investigated, and with strange results, is that of the direction of the inflected tentacles. And though he

has performed many experiments on the subject, and has inquired into the mode in which a stimulant is made to travel, yet we do not think he has added very much to our knowledge on the subject. His (or rather his son's) drawing, which represents a leaf of *Drosera* with its tentacles infolded over a piece of meat, is an admirable illustration. It shows the whole process so much better than words can convey it, and to our minds it is exceedingly like a sea-anemone that had just grasped a small crustacean. Well might the author say, "We might imagine that we were looking at a lowly organised animal seizing prey with its arms," and, further on, that "the case of the *Drosera* is far more interesting [than the motion of tendrils], as here the tentacles are not directly excited, but receive an impulse from a distant point; *nevertheless, they bend accurately towards this point.*" With regard to this very interesting process, the following attempted explanation is offered by Mr. Darwin:—"About the mechanism of the movements and the nature of the motive impulse we know very little. During the act of inflation fluid certainly travels from one part to another of the tentacles. But the hypothesis which agrees best with the observed facts is, that the motive impulse is allied in nature to the aggregating process, and that this causes the molecules of the cell-walls to approach each other in the same manner as do the molecules of the protoplasm within the cells, so that the cell-walls contract. But some objections may be urged against this view." After some further remarks the author truly says, "We see how little has been made out in comparison with what remains unexplored and unknown."

Mr. Darwin describes with the utmost minuteness his numerous experiments on some of these animal feeders, and it is perfectly astonishing to see the number of flies which a single specimen of some of the plants observed by him have captured. And the reader must not suppose that they are simply captured insects. They are regularly digested. The plant closes on them, and they are thus killed; and it is not till the whole of their soft parts have been dissolved and absorbed that they open, and thus reject the excrementitious matter. Thus it is that certain of these plants are provided with such imperfect roots; they do not require food supplied through the roots, because they are able to obtain a quantity through the multitude of insects they captivate. "There can hardly be a doubt," says the author, that these plants "have the power of dissolving animal matter by the aid of their secretion, which contains an acid, together with a ferment almost identical in nature with pepsin; and that they afterwards absorb the matter thus digested. This is certainly the case with *Drosera, Drosophyllum*, and *Dionæa*; almost certainly with *Aldrovanda*, and, from analogy, very probably with *Roridula* and *Byblis*. We can thus understand why it is that the three first-named genera are provided with such small roots, and that *Aldrovanda* is quite rootless; about the roots of the two other genera nothing is known. It is no doubt a surprising fact that a whole group of plants should subsist partly by digesting animal matter, and partly by decomposing carbonic acid." But Mr. Darwin instances as remarkable a fact in the Animal Kingdom by pointing to those peculiar rhizocephalous crustaceans which are absolutely destitute of an alimentary canal.

We cannot touch on any of the author's observations on the genus

Pinguicula, which are of extreme value, but we must now conclude our very imperfect notice of this Mr. Darwin's latest labour; and while we thank him most heartily for giving us so admirable a book, we confess that he has but opened up a vast field wherein future naturalists may reap rich harvests of experiment and observation.

TYNDALL ON LIGHT AND SOUND.*

TWO new editions of these splendid though in a certain sense elementary volumes are now before us, and demand a word or two in notice of their author's efforts at improvement of his former labours. The book on "Light" is of course very much as it was in the first edition, because in the department of Physics, to which it belongs, there has not been very much done to advance the science. Still, however, it has certain features of novelty. For example, there is the Appendix, in which are to be found three brief addresses by distinguished Americans, which, though short, are nevertheless eloquent and to the point. The portion omitted from the present edition is the reply of Dr. Young to the Edinburgh "Reviewers." This was introduced into the former edition, which was really an American publication, and it has served the purpose for which it was originally published. Hence it loses its place in the work now before us, and in its stead is an admirable engraving of Dr. Young, which has been well executed by Mr. Adlard, from the painting by Sir T. Lawrence.

It is in the "Sound," which is a work nearly twice the size of the former, and which is in its third issue, that the most remarkable additions have been made. Since the second issue the author has been carrying through (for the Trinity House) a very remarkable series of experiments, and he has been led by these to the formulation of certain doctrines which he thinks are definitely conclusive. On this point Professor Tyndall has been directly at variance with the conclusions already drawn up by the Light-house Board at Washington; a circumstance which is somewhat unfortunate, even though, as it seems most probable, Professor Tyndall is clearly in the right. It is on this account, doubtless, that the author enters at such length into the discussion of the entire question. And from a perusal of the facts, as set forth by Dr. Tyndall, it would certainly appear that he is clearly correct, and the Americans inaccurate in their account. This seems so from the fact, which is particularly dwelt on by the author, viz., that "the echoes have often manifested an astonishing strength when the sea was of glassy smoothness. On days when the echoes were powerful I have seen the southern cumuli mirrored in the waveless ocean in forms almost as definite as the clouds themselves. By no possible application of the law of incidence could the echoes from such a sea return to the shore; and if we accept for a moment a statement which Professor Henry seems to endorse, that sound-waves of great intensity, when they impinge upon a solid or a liquid surface,

* "Six Lectures on Light, delivered in America in 1872–73." By John Tyndall, LL.D., F.R.S. Second edition. And "Sound." By John Tyndall, LL.D., F.R.S. Third edition. London: Longmans, 1875.

do not obey the law of incidence and reflection, but 'roll along the surface like a cloud of smoke,' it only increases the difficulty. Such a cloud, instead of returning to the coast of England, would in our case have rolled toward the coast of France." It will be seen from the above that Professor Tyndall's case is clearly and strongly put before the reader. Time alone will tell what result it may have on the expression of opinion in America. The other parts of the book are equally valuable if not of so absorbing interest.

INSTRUCTIONS FOR THE ARCTIC EXPEDITION.*

HERE is a vast and most valuable work, specially prepared for the Expedition which left our shores a few months since, and which, we doubt not, will well repay the expenditure which must have been made upon it by the Lords Commissioners of the Admiralty. It extends to more than 850 pp. of large 8vo, with numerous illustrations intercalated with the text, and it is divided into two distinct parts. The first division has to do with the instructions that were given to the several investigators who are sent out in the present Expedition. The second, which covers over 750 pp., consists of a vast series of papers, collected and arranged by Professor Rupert Jones, F.R.S., and Professor W. G. Adams, F.R.S., and having to do with every possible branch of science which can in any way be brought to bear on Arctic matters. Finally, we may state that the entire work has been brought out—and most successfully it seems to us—under the charge of Professor R. Jones, F.R.S., whose labours must have been of a most exhaustive description. And this must have been especially the case from the extremely short time allowed to get the work through the press from the period when it was first begun. On this account the reader will naturally excuse any slight errata he may observe, and he will pardon the manifestly incomplete character of the index, which, had time permitted, should have been a most full and exhaustive one. Indeed, on this point we think the editor should even now be permitted by the Lords of the Admiralty to produce an elaborate index, for there is nothing more requisite to insure the usefulness of the volume.

So far as we can see, the information that is laid down in these instructions is the most valuable and concise that can be conceived. The astronomical observations are placed first in order [alphabetical we suppose], and they include Notices of Eclipses of the Sun in 1876 and 1877, by Mr. J. R. Hind; Suggestions for the Observations of Tides, by Professor Haughton; Pendulum Observations, by Professor G. Stokes; and Observations on the Detection of Meteoric Dust in the Snow, by Professor H. Roscoe. These are

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* "Manual of the Natural History, Geology, and Physics of Greenland and the Neighbouring Regions." Prepared for the use of the Arctic Expedition of 1875, under the direction of the Arctic Committee of the Royal Society, and Edited by Professor Rupert Jones, F.R.S. Together with Instructions for the use of the Expedition. London: Eyre & Spottiswoode, 1875.

followed by remarks on the use of magnetical instruments, by Professor Adams and Captain Evans. Meteorology is divided between Mr. R. Scott and Professor Stokes, the latter having given some notes on Auroral observations. Electricity is taken up by Sir W. Thomson, who gives valuable advice concerning the mode in which atmospheric electricity is to be observed and recorded. Optics is divided between Professor Stokes, who tells how observations are to be made on the spectrum of the sun and of the Aurora, Mr. Spottiswoode, who has to do with the polarisation of light, and Mr. J. N. Lockyer, who gives instructions on the use of the spectroscope. Under the title of "Miscellaneous Information," Dr. Rae dilates on saline matter in ice, though his views do not quite accord with those of other observers. Indeed, on this interesting point the reader can do nothing better than carefully peruse Dr. Walker's admirable ice-observations, which were published in the "Journal of the Royal Dublin Society," 1860, and are to be found in the present volume, at p. 640. In conclusion, we may mention Dr. Tyndall's observations, which are of considerable import.

The Biological portion of the "Instructions" first include Zoology. Under this heading we have papers by Dr. A. Günther on collecting specimens of mammalia and fishes, and making observations thereon; on the cetacea, by Professor Flower; on the birds, by Dr. Sclater; on the mollusca, by Mr. Gwyn Jeffreys; on the collection of hydroids and polyzoa, and on the method of using the towing net, by Dr. Allman; and, finally, one of the best papers is that by Professor Huxley, which contains supplementary instructions, and gives some useful hints as to modes of obtaining unusual forms, which otherwise would have been overlooked. Dr. J. D. Hooker has sole charge of the botanical instructions, and no one could have been selected more thoroughly qualified for the task, and he has availed himself of the experience of Dickie and of Archer in particular departments, and thus made his portion of the instructions most valuable reading. Lastly, the geology and mineralogy has been here done by Professor Ramsay, Mr. Evans, Professor Maskelyne, and Mr. J. W. Judd. These portions are well illustrated, and cover nearly 16 pp. with excellent advice to the student. It will be seen that up to this we have been only considering the subjects of advice to the students who are to follow out the several departments. Besides this, there are about 750 pp. of articles on the various subjects connected with Arctic discovery. To enumerate these, merely giving the titles of the several papers and their authors' names, would occupy nearly as many pages as we are accustomed to give to our entire reviews—*i.e.* about 10 pp. It is, therefore, alone requisite to state that all are of interest, and that some of the most old are unquestionably some of the best papers in the volume. In conclusion, we must express our opinion that our nation owes its thorough gratitude to the men who have at such a vast labour given their undivided experience for the immediate advantage of our polar navigators, and, therefore, in the end for the benefit of our people.

VICTORIAN ORGANIC REMAINS.*

THE second decade, like the first, noticed in a previous number (POPULAR SCIENCE REVIEW, April 1875), is varied in its contents and interesting as containing a continuation of the more characteristic fossils of each formation, of which good specimens are preserved in the national collection at Melbourne. The plates illustrate fossils of different geological periods. The decade includes a new species of Squalodon, from the tertiary sands of Cape Otway, a genus of carnivorous whales, hitherto only found in the Miocene tertiaries of Malta and Bordeaux, two species of Carcharodon from Geelong, also found in the miocene of Europe. Three plates illustrate some Mesozoic coal ferns, of which one, the *Pecopteris Australis*, is considered by Professor McCoy to be allied to, if not identical with, an oolitic fern from Yorkshire. Some curious forms of *Cypræa* are described from beds of presumed Oligocene age, differing in character from the usual living and Pleiocene species of that genus, but somewhat resembling the one figured in Count Strzlecki's "New South Wales." Also two tertiary species of Trigonia, a genus hitherto only known as abounding in the Mesozoic strata and at present in the Australian seas, "but the complete absence of which, in the intermediate tertiary periods, in all localities examined, was looked upon by geologists as a most curious exception to the general palæontological law of the distribution of genera in time—an exception we can now remove." (Preface, p. 5.) Further illustrations of the species of graptolites from the gold-field slates are continued in this part, all of which (with one exception, the *Retiolites Australis*, McCoy, from the Upper Silurian) are identical with examples of the same species occurring in rocks of the same age in Scotland, North Wales, Bohemia, and North America. The critical determinations of the fossils by Professor McCoy, made during the progress of the geological survey under Mr. R. Brough Smyth, will not only be of importance to the colony, but of much interest to the European and American geologists, as enabling them to observe the resemblance or difference of the fossils in strata of presumed similar geological age in the Northern hemisphere.

AMERICAN GEOLOGICAL SURVEYS.†

THE reports of the different geological surveys become more important and interesting, as showing the annual progress made in the exploration of each State, not only as regards their physical features, geological structure, and agricultural character, but also as to the distribution and

* "Prodomus of the Palæontology of Victoria." By Frederick McCoy, F.G.S. Geological Survey of Victoria. Melbourne: 1875.

† "United States Geological and Geographical Survey of the Territories, embracing Colorado." By F. V. Hayden. Washington: 1874. "Bulletin of the same Survey." No. 4. Second Series. 1875. "Fifth Annual Report of the Geological Survey of Indiana." By E. T. Cox. Indianapolis: 1874.

modes of occurrence of the various economical substances met with during the work of the survey. This is well shown in the elaborate report of the territories, embracing Colorado, by Dr. F. V. Hayden, embodying the results of the exploration for the year 1873 by himself and his colleagues, and adding another valuable contribution to our knowledge of the geography, geology, and natural history of an interesting portion of the United States. In fact, the publications connected with this survey since its commencement in 1867 already form a large library of works relating to the various branches of natural history of those parts of the region which have been surveyed. Fully illustrated with maps, sections, and plates, this volume contains the geology of the east slope of the Colorado range of the Rocky Mountains, of the Middle and South Park divisions of the State, and a report, by Mr. Endlich, on the mining districts of Colorado, with a catalogue of the minerals and the geology of St. Luis, in which district occurs distinct varieties of granite, forming the higher portions of the eastern edge of the front range, and is partially covered by volcanic rocks in the eastern and northern half of the district. The Palæozoic rocks are fairly represented, the Carboniferous being well developed, showing great uniformity in the groups of strata. A wide gap now follows, but the cretaceous strata are well defined, followed by the doubtful lignitic beds, which seem "to be of an age which can palæontologically be referred neither to the cretaceous nor to the tertiary," and above these are the tertiary, diluvial, and alluvial deposits. The second part contains an important chapter, by Professor Lesquereux, on the lignitic formations of the West, in which he still maintains their tertiary character, and refers them, from personal examination of the localities, to four periods—Lower and Upper Eocene, and Lower and Upper Miocene—and describes under each group the affinities of the plants with those found in the Arctic, Mississippi, and European floras of either Eocene or Miocene age. The same part contains a report on the vertebrate palæontology of Colorado, by Dr. E. Cope, from the formations which represent the cretaceous and tertiary periods. The third part is devoted to a description of the collections of Invertebrata made during the survey of 1873, chiefly by Lieut. W. L. Carpenter. The last part includes the geography and topography, by Messrs. Gardner and Gannett, with a list of the elevations of certain datum-points on the great lakes and rivers and in the Rocky Mountains. The "Bulletin" contains some interesting notes by Dr. Hayden on the surface features of the front range of the Rocky Mountains, which in the eastern ranges present a great variety of forms resulting from erosion, due partly to the effects of the glacial period and the subsequent combined action of water and ice; but it is possible that the great Rocky Mountain range was outlined in form far back in the past, perhaps even during the carboniferous period, though it received vast additions during the cretaceous and tertiary epochs. Professor E. T. Cox's report is a continuation of the progress of the survey of the different counties of the State, to which is prefixed a report on the iron and coal mining as exhibited in the last Vienna Exhibition.

THE CRETACEOUS FLORA OF AMERICA.*

AMONG the other valuable results of the United States Geological Survey of the Territories, under the charge of Dr. F. V. Hayden, is the memoir by Professor Lesquereux on the nature and character of the fossil plants obtained from the cretaceous Dakota group. This division, lying at the base of the cretaceous series, forms a most important link in the physical history of the western portion of the continent, containing as it does one of the early proofs of the introduction on the earth of a vegetation allied to our fruit and forest trees. The formation has a vast geographical extension both north and south, from the 39° to the 47° of north latitude, but the chief fossils obtained from it have been found in the eastern portions of Kansas and Nebraska. The interest connected with this flora, first noticed by Dr. Hayden in 1853, and belonging to a lower member of the American cretaceous formation, is that it presents a tertiary facies, differing essentially from the usual Mesozoic flora of cycads, ferns, and conifers, in containing an abundance of dicotyledonous angiosperms; for, of the one hundred and thirty recognised species, only twenty do *not* belong to that division of plants. Considered as a whole, says Professor Lesquereux, most of the types of the Dakota group related to those of our present flora represent a moderate climate, like the one prevailing now between the 30° to 45° north latitude. The vegetable types more distinctly characterised by their leaves, and which are recognised by all the palæontologists—*Salix*, *Platanus*, *Sassafras*, *Aralia*, *Magnolia*, *Lirisodendron*, *Menispermum*, *Rhus*, &c.—are all co-ordinate to identical climatic circumstances, or to the same average temperature which governs at our time the vegetation of the latitude indicated above. All these types are, therefore, present in the North American flora, some of them with scarcely any alteration of forms. Professor Lesquereux remarks that, on account of the deficiency of materials for comparison, there is little to say on the relation of the Dakota group flora with that of any of the cretaceous groups of Europe; still there is sufficient to prove with our present knowledge the truth of the assertion that the flora of the Dakota group, without affinity with any preceding vegetable types, without relation to the flora of the lower tertiary of our country, and with scarcely any forms referable to species known from coeval formations in Europe, presents in its whole a remarkable and, as yet, unexplained cause of isolation. Geologists must thank Professor Lesquereux for this important contribution to Palæobotany, not only for the detailed description of each species and the careful illustration of their forms on thirty well-executed plates, but also in bringing before us in a clear and interesting manner the character of the land vegetation of the cretaceous period in Western America, so as to contrast or compare it with the terrestrial floras of the synchronous period in Europe, and thus assisting us to restore in part the extent and nature of the land surface bordering the old extensive chalk sea, whether in some cases it was low islands or low shores, or in others hills and dry lands upon which the trees grew.

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* "Contributions to the Fossil Flora of the Western Territories." Part I. "The Cretaceous Flora." By Leo Lesquereux. Washington: 1874.

THE BIRDS OF MISSOURI.*

THIS work on the ornithology of the Missouri region is another result of the Geological Survey of the Territories under the charge of Dr. F. V. Hayden. The author, Dr. E. Coues, has been long engaged on the subject, and the basis of the present volume is mainly an unpublished report, prepared in 1862, on the collection of birds made by the naturalists of the expedition under Captain Reynolds, as well as that obtained in previous explorations conducted in 1856–57 in the region of the Upper Missouri and Yellowstone Rivers. This work of nearly 800 pages is not a mere catalogue of birds, but contains a very complete synonymy of the different species, with references to the observations of previous authors, and to the expeditions when the birds were obtained. The habitat and general distribution of each species, and the course and period of their migrations, and their nesting and wintering, are generally indicated. Besides which, there is a critical examination of the various nominal species and varieties established upon conditions of immaturity and dependent on climatic variation, a good example of which is found under the description of the hairy woodpecker, page 280, and of descent, with modification, under the grey-headed snow-bird, page 143. Interesting and instructive accounts of the habits of some birds are frequently introduced, such as the Missouri skylark, the clay-coloured sparrow, blue jay, yellow-billed cuckoo, burrowing owl. The physical features of the Missouri water-shed are somewhat various; much of the western portions are mountainous, and extensive areas are cut up by the *mauvaises terres*, or "bad lands." It results from these physical conditions that the avi-fauna is not rich; there is no single species absolutely confined to it, still several abundant and generally diffused species may be said to be characteristic of it. The great number of species treated of in this volume is due to accessions from both the eastern and western faunal provinces, as well as those species of general diffusion over the continent, as most *Raptores* and *Lammellirostres*. The genera are arranged under their respective orders, and many copious and valuable notes from the observations of Messrs. Trippe, Allen, Gentry, and others enrich the volume, so as to render the work not only useful to European naturalists but to American ornithologists, as forming a hand-book to the ornithology of the region drained by the Missouri River and its tributaries.

GEOLOGY OF MISSOURI.†

THIS report, by Mr. G. C. Broadhead, of nearly 800 pages, is of a very practical character, and contains the result of the field-work in the State of 1873–74. The plan for the past year having been to look after those items of the greatest interest and economic value, and to present the facts in

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* "Birds of the North-west." By Dr. E. Coues. United States Geological Survey of the Territories. Miscellaneous Publications, No. 3. Washington: 1874.

† "Report of the Geological Survey of the State of Missouri." By G. C. Broadhead, State Geologist. Jefferson City: 1874.

the simplest form, so as to be easily understood by the general reader, we are thus presented, under each of the counties surveyed, with their physical features, the general and economical geology, the minerals found, the nature of the soils, the timber, the various mineral springs, and the supplies of water. The chief geological formations of the State, besides the occurrence of granite and porphyry, are of Palæozoic age, including the Silurian, Devonian, and Carboniferous strata; the Mesozoic rocks do not appear to be represented, the more recent or quarternary accumulations belonging to the drift, bluff, and alluvium. The Missouri coal-field is estimated at about 23,100 square miles; the upper measures, about 8,000 square miles, are mostly barren of coal, or only contain an occasional seam too thin to pay for working. The extent and character of the coal formations are more fully treated in each of the county reports. Besides a great amount of information embodied under the respective counties surveyed by Mr. G. C. Broadhead and Mr. Norwood, the latter half of the volume contains an elaborate account of the lead and zinc regions of the Central and South-western Missouri, by Adolph Schmidt and Alexander Leonhard, giving their general characteristics, and special descriptions of the ores and associated minerals, their mode of occurrence and nature of the deposits, and of the mining and smelting of them. There is also a report on the iron ores of South-eastern Missouri by Mr. Moore, of the history of lead mining by Mr. Cobb, and of the lead mines of Upper Louisiana by Mr. Austin, and of the chemical work and analysis done in connection with the survey by M. Chauvenet. The work is further illustrated by ninety-one figures of the deposits of ore, and an atlas of maps and coal sections of the counties explored.

THE SCIENCE OF LANGUAGE.*

THE international scientific series of works which has been commenced by Messrs. King and Co. is, so far as we have seen the books, unsatisfactory on the whole. We think there has been an absence of scientific judgment in the selection of some of the subjects, and we might add also of some of the writers. There are, in the entire set of works which have been issued, very few which have a real value. Unquestionably, however, some of the books have been excellent in character, and we wish we could say the same for the volume under notice at present. Professor Whitney has, we believe, written an earlier and a better work on the subject of language; but assuredly he has in the present instance done, we might say, nothing towards producing a book which in any way gives a proper idea of the subject. It is simply ludicrous to observe the manner in which he apologises to his readers for want of space in which to place his ideas fully before them. Why, the book is nothing more than "words, words, words." It assuredly is worthy of its title in so far as it simply illustrates "the growth of

* "The Life and Growth of Language." By William Dwight Whitney, Professor of Philology in Yale College. King and Co. 1875.

language." The author has such an intolerable flow of words, and his mode of expression is so long, instead of being terse and brief, that at least half of the present work is occupied with long-winded sentences, which convey very little significance. Then, while he evidently desires to have his subject styled a Science—as it unquestionably should be—he utterly omits everything like a scientific method in his teaching. For instance, he plunges at once into the very midst of his subject, instead of leading his reader on, step by step. We must confess to an utter dislike of Professor Whitney as a teacher, for to us he seems alike to want both clearness of expression and scientific method of putting his facts together. One of the best chapters in the present work is that on local and class variation of language—in fact, dialects. In this he shows the mode in which dialects are formed, and he observes with perfect justice, that many of the so-called Americanisms and Irishisms are simply the older forms of the English tongue itself, which, while still extant in America and Ireland, have died out of the English soil. The other chapters are *tout ensemble* unsatisfactory, and with this expression of our views we close this notice.

A MANUAL OF BEE-KEEPING.*

MR. HUNTER has done a good work in giving this little book to the apiarian. He has told us in something over a couple of hundred pages everything we require to know as an amateur bee-lover. The author is the honorary secretary of the British Bee-keepers' Association, and is therefore not only thoroughly familiar with the natural history of the Bee, and with the different varieties which have been introduced into this country, but he is also familiar with the various processes that have been adopted in the management of the hive. To be sure, as the author observes, his book is not to be compared with that of Langstroth; but then the purchaser will remember that the price is four times as much as Mr. Hunter's little work. There is nothing that relates to bees and bee-keeping that does not find a place in this small book. First we have ample information on the subjects of Hives, Supers, Ekes, and Nadirs, Feeders, Queen-cages, Bee-houses, the Honey-extractor, Drone-traps, Guide-combs, quieting bees, driving, natural and artificial swarming, Queen-breeding, Ligurian bees and the mode of Ligurianising an apiary, transferring bees and combs to an apiary, removing supers, robbing, feeding, pollen, ventilation, &c. Then there comes a series of chapters on stings, the method of removing bees, the pasturage for bees, the "diseases" and enemies of these industrious little creatures, on combs, draining honey from them, on the uses of honey and the preparation of wax; and the book ends with three chapters on propolis, profits, and a calendar which tells you what you are to do with your bees as every month goes by. The most interesting chapters in the book are the first, which treats of the natural history of the honey-bee, and which is of value, notwithstanding

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* "A Manual of Bee-keeping." By John Hunter, Hon. Sec. British Bee-keepers' Association. London: Hardwicke. 1875.

that the author opposes Sir J. Lubbock's well-established views on some points; that which deals with the subject of hives; that on drones and bee-traps, which describes some very simple modes of getting rid of the drones, which are larger in size than the workers; and, finally, that on pasturage for bees, which shows that bees may well be kept, even in busy London—a lady having kept many hives in the neighbourhood of Kensington.

GANOT'S PHYSICS.*

WE think that Dr. Atkinson was quite right in his determination to translate this more popular work of Professor Ganot rather than to attempt to render the *Éléments de Physique* simple enough for the school pupil. The present work is in great measure a translation of M. Ganot's *Cours élémentaire de Physique*, with, of course, certain additions and alterations, which commended themselves to Dr. Atkinson. It is certainly an admirable work, and it is what our English books—with the exception of Lardner and Deschanel's, which is also a translation from the French—all fail in, very excellently illustrated. We have looked through it, and we think the author's clearness of style has been thoroughly maintained by the translator. Of course the book is in no way to be compared to the *Éléments*; still it is most excellent as a handbook for either the medical student or for the candidate for matriculation at the London University. "Comparisons are oderous," of course, but we must certainly say that, on the whole, while M. Deschanel's book was in the hands of the English student, M. Ganot might have been dispensed with. In any case, however, it has reached a second edition.

SOUTH AFRICAN HYDROLOGY.†

ALTHOUGH we fear that this book is not likely to find numerous readers, yet it is certainly worthy of being largely read. It is a work on which a considerable deal of thought has been expended by its author in order to prove conclusively the immense necessity which exists at the Cape for the Government to take in its charge the management of the forest district. Dr. Brown has, in our opinion, conclusively shown, by a wide and varied argument, that the immense drought which now exists from time to time in South Africa is caused by the absence of forests in certain localities. And if further evidence were required on this subject, it is to be found in the testimony which has been supplied to the French Academy by the various officers whom it has deputed to investigate and report on the subject. In-

* "Natural Philosophy for General Readers and Young Persons." Translated and edited, from Ganot's *Cours élémentaire de Physique*, by E. Atkinson, Ph.D., F.C.S., Professor of Experimental Science in the Staff College. Second edition. London: Longmans. 1875.

† "Hydrology of South Africa, and Causes of its Present Aridity." By J. R. Brown, LL.D. London: King & Co. 1875.

deed, there are many competent authorities who assert that the recent painfully disastrous floods that have happened in the South of France would have never occurred had the upper districts been properly clad, as they once were, with large vegetation. This book of Dr. Brown's shows us clearly that such was the case in South Africa, and that the result has been a certain amount of aridity of the soil which will not, he opines, be removed till some attempt to re-clothe the ground with large vegetation is made.

PHRENOLOGY.*

THIS is a book that we are surprised to see bearing the name of Longmans as its publisher. It is one written by a man who is evidently a "Professor" of Phrenology, and who is ignorant of anatomy. It is something better than most books of its class, but it is not by any means a scientific work.

SMITHSONIAN REPORT.†

AS usual, the first part of the Report is occupied with the business reports, monetary matters, &c., of the institution. But the latter half of the volume is filled with a series of memoirs, some of which are of extreme interest and importance. And first, we would call attention to the splendid memoir of Mr. H. Gilman, on "The Mound-builders and Platycnemism in Michigan." Perhaps our readers may not know what *Platycnemism* may signify. We shall, therefore, say that it refers to the habit among ancient races of American Indians of flattening the *tibia*, or leg-bone. And on the remains of this interesting group Mr. Gilman gives ample information, his remarks being illustrated by several explanatory wood-cuts. Other papers of considerable interest and importance are those on "Agassiz," and on "Charles Babbage." There is, too, a reprint from *The* (London) *Academy* of a capital paper by Professor Helmholtz, on "The Connection between Electricity and Magnetism." Dr. Dalton, too, contributes a noteworthy essay on "The Origin and Propagation of Disease." Other articles in the volume are, "On Warming and Ventilating Buildings," by M. A. Morin; "The Leipsig Museum of Ethnology," by Herr O. T. Mason; and a mathematical paper of interest, entitled "Additions to a Memoir on Methods of Interpolation applicable to the Graduation of Irregular Series," &c.

* "The Skull and Brain: their Indications of Character and Anatomical Relations." By N. Morgan. London: Longmans. 1875.

† "The Annual Report of the Board of Regents of the Smithsonian Institution for the year 1873." Washington, U.S.A.: Government Printing Office, 1874. [Though dated 1874, it did not reach us till after the July No. of the POPULAR SCIENCE REVIEW was issued in 1875.—ED. *P. S. R.*]

SUPPLEMENT TO WATTS'S DICTIONARY.*

HERE is a supplement to the valuable dictionary of Mr. Henry Watts, F.R.S., and when we observe that it is the second supplement to that work, the non-chemical reader will possibly imagine that it is a not very important volume. But we must point out to all such that the present work is a most valuable as well as a huge production. It is really the work not only of the Editor, but also of Professors Armstrong, Foster, and Roscoe, Dr. H. N. Martin, and Mr. R. Warrington. And these gentlemen have given us over twelve hundred large 8vo pages in small type; in fact, they have brought the work down completely to the end of the year 1872, and have incorporated many of the more important results made known in the years 1873 and 1874. It would be out of place here, as, indeed, it would be almost impossible, to contrast the authors' labours. Each seems to have done his part well, and we observe that the language is clear and to the point. It was, of course, not to be expected that all the writers would have held the same ideas as to theoretical questions, but there is a general accordance of opinion expressed, which is extremely satisfactory. The articles which strike us as of most interest and value are those on the "Constitution of Benzine," and on "Chemical Action." We think the type should have been more distinct for the titles and sub-titles; as it is, there is sometimes difficulty in saying which is which.

SHORT NOTICES.

"Astronomical and Meteorological Observations made during the Year 1872 at the United States Naval Observatory." By Rear-Admiral B. F. Sands, U.S.N. Washington: Government Printing Office, 1874.—This is a huge 4to volume, of a series of reports of interest to astronomers. The observations have been made with the Mural circle, the Transit circle, and the Equatorial.

"The Fifth English Reading-book." By Thomas Turner, F.S.S. And "The Fourth English Reading-book." London: Simpkin & Marshall.—We suppose that these two elementary school-books were sent to us because they contain short sketches of the life of scientific men. We think them on the whole good, though they are excessively elementary.

Sach's Botany.—Macmillan, 1875. We regret that our continued notice of this work, which was partly reviewed in our last number, has been unavoidably "crushed out."

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* "A Dictionary of Chemistry, and the allied Branches of other Sciences." By Henry Watts, B.A., F.R.S., F.C.S., assisted by eminent contributors. Second supplement. London: Longmans, 1875.

SCIENTIFIC SUMMARY.

ASTRONOMY.

ASTRONOMY in the Arabian Nights.—In the "Astronomical Register" (August, 1875), Mr. G. J. Walker says:—"While comparing lately the Boulak edition of the 'Arabian Nights' with Lane's excellent translation, I noticed for the first time the following passage occurring in the 756th night: 'Fáris the Wezeer of the king of Egypt answered, "We worship the sun, and prostrate ourselves to it." Asaf therefore replied, "O Wezeer Fáris, verily, the sun is a star, of the number of the stars created by God [Inna al-shams kaukab min jumlat al-kanakib al-makhlukat li'llahi] (Whose perfection be extolled, and whose name be exalted!), and far be it from being a lord! for the sun appeareth at times, and is absent at times, and our Lord is always present, never absent, and he is able to effect everything."' (Lane, iii. pp. 311, 312.) If it may be reasonably assumed that these famous tales have been circulated in their present form since the commencement of the sixteenth century (see Lane, iii. p. 739), the above analogy between sun and stars is rather interesting. Those who in Cairo and elsewhere listened to or read this passage had, so far, more just views of the universe presented to them than probably most of even the educated contemporary inhabitants of Europe for a long time entertained. It will be remembered that the unfortunate Giordano Bruno, in his work published in 1591, maintained that each star is a sun about which planets revolve; but the sequel of this tale is more pleasant to think of than the fate of Bruno, for we find that the Wezeer Fáris finally 'embraced al-Islam, he and they who were with him.'"

On Mr. De la Rue's Telescope in the New Observatory at Oxford.—Mr. De la Rue said in a recent paper read before the Royal Astronomical Society of London: "It may be of interest to the Fellows of our Society to know that the instruments which I presented some time back to the University of Oxford are now placed in position in the New Observatory erected by that body in the Park. These instruments comprise my 13-inch reflecting equatorial, used by me, first at Canonbury, and lastly at Cranford; a zoneing altazimuth with a 13-inch speculum; a polishing machine, with every appliance necessary for polishing both parabolic and plane mirrors; and also Foucault's apparatus for testing mirrors. In all these are four interchangeable 13-inch mirrors, two of metal polished by myself, one of glass by Steinheil, and one of glass by With. Observations are now being made

by Professor Pritchard, to enable me to make the very minute final adjustments of the equatorial. While making observations for the preliminary adjustments I inadvertently used my left eye, and was surprised and delighted to find that I had recovered perfect vision with it, the granulations in the centre of the retina having disappeared."

The Johnson Memorial Prize.—The Trustees of the Johnson Memorial Prize for the encouragement of the study of astronomy and meteorology propose the following subject for an essay:—"The History of the successive Stages of our Knowledge of Nebulæ, Nebulous Stars, and Star-clusters, from the time of Sir William Herschel." The prize is open to all members of the University of Oxford, and consists of a gold medal of the value of ten guineas, together with so much of the dividends for four years on 338*l.* Reduced Annuities as shall remain after the cost of the medal and other expenses have been defrayed. Candidates are to send their essays to the Registrar of the University, under a sealed cover, marked "Johnson Memorial Prize Essay," on or before the 31st day of March, 1879; each candidate concealing his name, distinguishing his essay by a motto, and sending, at the same time, his name sealed up under another cover, with the same motto written upon it.

Discovery of New Planets (147 *and* 148).—The "Astronomical Register" (September) publishes the two following letters:—

"Vienna: July 15, 1875.

"In the night of the 10th to the 11th July I noticed in a constellation of stars with which I was familiar, a faint little star of the 12th magnitude, the distance of which from A. Oe. 2,051 °/1 I estimated at about 13h. to be +3s. and +3′, but I did not succeed in taking an observation, properly speaking. On the following morning I was enabled to establish that it is in truth a planet. As yet I have obtained the following position thereof:—

1875.	Vienna M. T.	R. A. app.	Decl. app.
July 11	12h. 59m. 23s.	20h. 19m. 22·78s.	−17° 29′ 53·6″
" 12	13h. 55m. 55s.	20h. 18m. 36·06s.	−17° 31′ 52·8″
" 13	12h. 49m. 0s.	20h. 17m. 53·07s.	−17° 33′ 47·0″

Magnitude 12·0.

The Director of the Observatory, Professor Carl von Littrow, has been so good as to select the name 'Protogeneia' for the planet.—L. SCHULHOF.

By M. PROSPER HENRY, of Paris:—"1875, August 7th, 12h. 50m. M.T. Paris; R. A. (148), 22h. 39m. 3s.; N. P. D., 101° 11′·5. Hourly motion, −1·3s. +36″. Magnitude 10·7."

Study of the Solar Surface.—At the recent meeting of the American Association, Professor S. P. Langley, of Alleghany Observatory, detailed some of the conclusions at which he had arrived after years of study of the solar surface. Professor Langley first showed by comparative experiments that an absorptive atmosphere surrounds the sun. Little attention has in recent years been paid to the study of this atmosphere. The earlier efforts to tabulate its absorptive power, produced with different observers, though men of eminence, strangely discordant results. Their methods and deductions were given in detail. Secchi's results, making the neighbourhood of the edge of the sun about half the brightness of the centre, are probably

near the fact. Professor Langley applied well-known photometric methods to the problem. By attaching a circle of cardboard to the equatorial telescope, a solar image is received on the board, plainly showing spots, penumbræ, &c., if the image be one foot in diameter. From holes in this cardboard pencils of rays issue, which being caught on a screen give a second series of images. If these images are caught upon separate mirrors, instead of a screen, their relative light can be made the subject of comparison with that of a disc of flame from Bunsen's apparatus, and thereby their relative intensity determined. Between each aperture and its respective mirror a lens was interposed which concentrated the pencil of rays. By suitable additions this apparatus can be converted to a Rumford photometer, and in this form it proved most available in Professor Langley's hands. He found a value for the brilliancy of the umbra in sun-spots considerably higher than that hitherto computed. The blackest umbra, he finds, is between 5,000 and 10,000 times as bright as the full moon. The light of the sun is absorbed by its atmosphere not in the same, but in a greater proportion than its heat. A long series of experiments shows that not much more or less than one-half of the radiant heat of the sun is absorbed or suffers internal reflection by the atmosphere of the sun itself. Observations indicate that this atmosphere is (speaking comparatively) extremely thin; Professor Langley is inclined to regard it as identical with the "reversing layer" observed by Dr. Young, of Dartmouth, at the base of the chromosphere, though the chromospheric shadow should perhaps be taken into the account. The importance of a study of this absorbent atmosphere becomes evident if we admit that the greater part of the 500° which separate the temperature of the temperate zone from absolute zero is principally due to the sun's radiation. To this atmosphere new matter is constantly being added and taken away by the continual changes of the interior surface. Any alteration in the capacity for absorption—say a difference of 25 per cent., which could hardly be recognised by observation —would alter the temperature of our globe by 100°. The existence of life on the earth is clearly dependent on the constancy of the depth and absorption of this solar envelope. Hitherto we have chiefly confined calculations to the diminution of solar heat by contraction of the sun's mass—an operation likely to go on with great uniformity. But here is an element of far more rapid variation. If changes in the depth of this solar envelope are cyclical, they would be accompanied by cyclical alterations of the earth's temperature. This may serve alike to explain the characteristics of variable stars and the vast secular changes on earth indicated by geology. If the law of alterations in that envelope can be ascertained, new light may be shed on the history of the globe and the near future of life upon it.

Changes in Indian Observatories.—The "Astronomical Register" (August) understands that Government will, in all probability, sanction the transfer to Simla of the magnificent set of astronomical instruments now in charge of Colonel Tennant at Roorkee; and also the establishment at the former station of a permanent observatory, under the direction of the gentleman whose observations of the transit of Venus at Roorkee elicited so much admiration.

Diameter of the Sun.—From a discussion of the Greenwich observations,

1836-1870, Dr. Fuhg obtains, "Astron. Nach.," 2,040, 32′ 2″·99 as the diameter of the sun deduced from 6,827 measurements.

The Transit of Venus seen from Pekin.—Mr. Watson, at one of the September meetings of the French Academy, read a long and interesting paper on the observations of the Transit of Venus made at Pekin station, of which he was the chief. The question of the atmosphere of Venus, and the difficulty of determining the exact time of real contact were examined at full length. M. Leverrier expressed his decided opinion that the determination of the parallax of the sun by this method was useless unless some unexpected service should be rendered by photography for solving the difficulty raised by Mr. Watson. Mr. Watson tried to discover to what height the atmosphere of Venus was liable to cause optical disturbances by its illumination by the sun, and he found it to be fifty-five miles, about 1-70th the diameter of the planet.—See "Nature," September 16.

Death of Professor d'Arrest.—"Silliman's American Journal" says that Professor Heinrich d'Arrest, of the University of Copenhagen, died on the 14th of June, in his fifty-third year. The most important of the labours of this distinguished astronomer were the construction of two catalogues, the one of nebulæ observed by him at Leipzig, the other of nearly 2,000 nebulæ observed by him at Copenhagen. For these observations the Royal Astronomical Society of London awarded to him this year their gold medal.

America's Loss of an Astronomer.—It appears that Joseph Winlock was born February 6, 1826, in Shelby County, Kentucky. Graduating in 1845 at Shelby College, he afterwards held the professorship of Mathematics and Astronomy in that institution until 1852. The remainder of his life was passed chiefly at Cambridge, Mass.; but he spent some months at the U.S. Naval Observatory in Washington, and for more than a year was at the head of the mathematical department of the U.S. Naval Academy at Annapolis. He was twice made superintendent of the American Ephemeris, finally quitting this office in 1866 to take the post of Phillips Professor of Astronomy at Harvard University, and in that capacity to serve as Director of the Observatory. He held this office at the time of his death, June 11, 1875. His last illness was short, and did not appear dangerous until a few hours before its termination.

The next Return of Encke's Comet.—"Nature" of September 16 says that "the appearances of this comet at nearly ten-year intervals in 1819, 1829, 1838, 1848, 1858, and 1868 took place under circumstances which were more or less favourable for observation in this hemisphere; these conditions, however, will not attend the ensuing return to perihelion, which, with the mean motion found by Dr. von Asten for 1875, neglecting the small effect of perturbation, would occur about the 27th of July, 1878; and if the path in the heavens be calculated on this assumption, it will appear that observations will hardly be practicable except in the southern hemisphere in August. The nearest approach to this tract is that which the comet followed in 1845, when a few observations only were obtained with difficulty at Rome, Washington, and Philadelphia. With regard to the effect at perturbation upon the length of this comet's period since the year 1819, when its periodicity was first detected, it may be remarked that the longest revolution was that from 1842–45, which extended to 1,215·6 days, and the shortest, that from 1868–71, 1,200·2 days; difference of extremes, 15½ days.

The New French Physical Observatory has had M. Janssen appointed to be its Governor. Doubtless the position is worthily merited, but we doubt not there were some astronomers in Paris who will not think with the Government on this subject.

Irish Observations on Double Stars.—A discussion of the elements of the orbits of σ Coronæ, τ Ophiuchi, γ Leonis, ζ Aquarii, and 36 Andromedæ, by Dr. Doberck, of Colonel Cooper's Observatory, Markree, forms Part 19 of vol. xxv. of the "Transactions of the Royal Irish Academy." Dr. Doberck employs the graphical method proposed by Sir John Herschel, which has been so generally applied, at least in the earlier part of the work. Correction of the approximate elements thus obtained by equations of condition will lead to satisfactory results where there are reliable single epochs, or a sufficient number of contiguous ones, to enable us to form normals. It may be questioned whether the additional labour of calculation which some of the methods of calculating double-star orbits that have been proposed necessarily involve, is rewarded by more satisfactory results that can be obtained by the application of Herschel's graphical process in the first instance, following up by equations of condition.

BOTANY.

A peculiar Fungus found in a White Ant-hill.—"Grevillea" gives a long account of a species found in an Indian ant-hill, and it furnishes the report made upon it by Dr. D. Cunningham, who says: "I herewith return the letter sent to me more than a month ago, along with specimens of fungi said to have been procured from the interior of a white ant-hill. The specimens apparently belong to some species of *Lepiota*, and are chiefly remarkable for the extreme length and coarse fibrous contents of the stem. The occurrence of fungi in connection with ant-hills is well known, but in so far as I am aware those hitherto described as occurring on the hills of the white-ant belong to species of the Gasteromycetous order, *Podaxinei*, so that the occurrence of a species of one of the sub-genera of *Agaricus* in such localities is a new and interesting fact. With regard to the material from which they arise, and which must apparently be of the same nature as the so-called spawn of the cultivated mushroom, consisting of vegetable débris permeated by the mycelium of the fungus, it may be noted that a similar substance is described by Belt as occurring in the nests of the leaf-culling ants of Nicaragua, and is supposed by him to serve as food—the ants culling and storing the leaves for the sake of the fungi which are subsequently developed in the débris. ("Naturalist in Nicaragua," pp. 80.) Were this spawn artificially exposed to conditions similar to those which it naturally encounters in the interior of the hillocks—heat, darkness, and moisture—I believe that the pilei might very probably be raised at will, and if they really are good eating the experiment would be well worth trying."

The Flora of India.—"The Academy" says that the first volume of Dr. Hooker's "Flora of India" is the principal contribution to descriptive botany of the present year. This is a work that is greatly needed, as we possess

none approaching completeness on the vegetation of the country that is probably richer in vegetable products than all the rest of our dependencies put together. The present volume contains comparatively little that is absolutely new—that is to say, descriptions of new genera and species; but its chief value is in being a compendium, so far as it goes, of all the plants known to grow in the country, written in English. It contains the polypetalous families from the Ranunculaceæ to the end of the Sapindaceæ, embracing descriptions of 442 genera and 2,250 species. Dr. Hooker's "Student's Flora of the British Islands" has been followed in the style and arrangement of the matter, which has caused a considerable saving of space, as compared with similar works. Several botanists have contributed to the present volume; but even with the united labours of half-a-dozen contributors, the completion of the work cannot be effected in less than as many years. The species number from 12,000 to 14,000, scattered over an area of 1,500,000 square miles, representing every variety of climate.

The Chemistry of Phormium tenax.—Professor S. Church has worked this out, among various others that he has written upon in "The Journal of Botany." He says: "The two reports on the chemistry of *Phormium tenax* which I have addressed to the Flax Commission of New Zealand contain many points of interest in connection with this subject. These reports will shortly be published in the form of an abstract, but in the meantime I may select from them the following curious observations as to the effect of water at a high temperature on tissues containing lignose, and on the indifference of cellulose to such treatment. When pure cellulose, prepared from cotton as just described, was boiled for twelve hours with distilled water, it gave up no appreciable amount of organic matter to the water, which did not acquire an acid reaction. Even in a sealed tube, at a temperature maintained at 150° C. for four hours, water was almost without effect on cotton. But with Phormium fibre a small quantity, about 4 per cent., of an acid yellow extract was obtained even by simple ebullition with water at 100° C.; while at 150° to 160° C. water causes so great a change in the material that it dissolves in quantities amounting in different specimens to 19, 24·4, and even 33·3 per cent. of the dry fibre taken. The nature of the products formed has been in great measure investigated, a kind of sugar and an acid body occurring amongst them. But the point to which I wish now to direct attention is the test which water at high temperature affords of the presence or absence of the so-called secondary deposits. We know that lignose is coloured yellow, brown, or red by strong nitric acid, and that, in the purest state in which it has yet been separated, it is richer than cellulose in carbon by about 10 per cent. But the employment of water under pressure and at different temperatures above the boiling point may enable us to take a further step in this inquiry, and to ascertain whether lignose is a mixture or a homogeneous substance. And we may then hope to obtain by other methods of research some insight into its chemical constitution and its physiological production."

CHEMISTRY.

A Pure Dextrin from the Action of Diastase on Starch has been recently described by M. Bondonneau (in the "Bull. Soc. Chim." II. xxiii. 98). A kilogram of dry starch, diffused in two litres of water, was treated in the cold with an extract of 250 grams of bruised malt in 500 grams of water; the whole being heated on the water-bath to 75° until the starch had disappeared. The liquid was then carried to boiling to destroy the diastase, filtered through animal charcoal, and concentrated to 32° – 33° Baumé. To free the dextrin in this solution from the glucose (dextrose) present, it was first reprecipitated five or six times with alcohol, then treated with a copper test made with cupric chloride and sodium hydrate; this latter treatment destroying the dextrose. As thus obtained, the dextrin showed no coloration with iodine, gave only feeble indications with the copper test (equivalent to 1·85 per cent. dextrose), reduced gold chloride and ammonio-silver nitrate, gave an abundant precipitate with a solution of barium hydrate and with ammoniacal lead acetate, but none with lead sub-acetate. The dextrose present the author believes to be produced by small quantities of non-coagulable albuminoids present, acting as ferments. By care and rapidity in operating, dextrin may be obtained devoid of reducing power. The rotary power of the dextrin thus obtained is $aj = 176°$ to the right; that produced by torrefaction being $aj = 183°$.

A Substance in the Urine after taking Chloral Hydrate.—In a late number of the "Comptes Rendus," MM. Musculus and De Mermé have published a paper on this important subject. They say that foreign substances introduced into the human organism are rejected in states which may be divided into three groups:—1. Bodies which pass unaltered through the system, such as creatin, acetamid, &c., and are found unchanged in the urine. 2. Bodies which are decomposed, and whose decomposition products are found in the blood, the saliva, and the urine, such as leucin and glycocoll, which yield urea. 3. Bodies which combine chemically with some product of the organism, and thus pass into the urine. The type of this group is benzoic acid, which combines with glycocoll, and is eliminated as hippuric acid. In the urine of dogs poisoned with chloral hydrate, Feltz and Ritter have recently discovered chloral, sugar, and another organic substance precipitable by the basic acetate of lead. It is an acid which forms stellar groups of crystals resembling those of tyrosin, and containing —

Carbon	31·60
Hydrogen	4·36
Chlorine	26·70

It is not expelled from its salts by acetic acid. At the boiling-point it reduces alkaline solutions of copper and bismuth, and salts of silver, and decolourises sulphate of indigo. It turns the plane of polarisation to the left. The authors hold that chloral should rank in the third group with benzoic acid, and propose for the acid found the provisional name of urochloralic.

Milk in Health and Disease.—This important subject has been lately

explored by Mr. A. H. Smee, who read a paper on it before the Chemical Society on one of the last evenings of the session. He found that, although milk taken from herds of cows exhibits great uniformity in composition, yet the milk from individual cows is liable to considerable variation; moreover, it is possible for good average milk to be watered to a limited extent without detection. He observed, also, from a comparison of the milk from cows fed on ordinary meadow grass and on grass from a sewage farm, that in the latter case the milk went putrid after thirty-six hours, and the butter became rancid rapidly compared with that made from the milk of cows fed on ordinary meadow grass. These effects were more apparent in spring than in the latter part of the summer. On three or four occasions, also, he noticed that when the milk of cows fed on sewage grass was placed on a dialyser, the casein passed through the membrane, from which it would appear that the casein existed in these milks in a modified form. He then proceeded to notice the outbreaks of typhoid fever which had occurred at various places owing to sewage water having been used to cleanse the dairy utensils, or to reduce the quantity of rich milk to the lowest standard allowed by law, showing how important it was that there should be a supply of pure water to every dairy. Moreover, milk which had been exposed to sewage-gas from an untrapped drain, although on analysis it appeared to be unaltered in composition, yet when distilled at a low temperature (160° F.) it yielded a distillate which had a very offensive smell. It also caused intense headache, which was followed by diarrhœa. He also examined the milk of cows suffering from foot and mouth disease and from milk fever, and thought that the methods employed by Public Analysts were not sufficiently delicate to detect the slight physiological changes which may take place in so complex a fluid as milk.

A Method of modifying the Explosiveness of Methyl-nitrate.—This substance, which has caused the death of Dr. Chapman's distinguished son, has been recently experimented on with a view to render it harmless. M. Girard, who has been employing it largely for the production of colours, has made some experiments with it with this view. He finds, for example, that methyl-nitrate, like nitro-glycerin, detonates by a blow; a drop on blotting-paper producing, when placed on an anvil and struck with a hammer, an explosion quite as violent as nitro-glycerin. When mixed with pulverulent or porous substances, such as precipitated silica or infusorial earth, it yields dynamites fully as effective as those made with nitro-glycerin. By admixture with other liquids, however, such as methyl, ethyl, or amyl alcohol, acetone, benzol or toluol, Girard finds that it is no longer explosive. One part of methyl nitrate diluted with two or three parts of either of the liquids above named does not explode either on heating its vapour or by a blow. In such solutions, therefore, it is best kept for use.

GEOLOGY AND PALÆONTOLOGY.

The Ceratodus: a Fossil, and not a Fossil.—At one of the recent meetings of the Academy of Science of Philadelphia, Professor Leidy said that, "Of certain specimens presented to the Academy, one of these is a specimen of the *Ceratodus Forsteri*, from Queensland, presented by Dr. John Belisario, of Sydney, Australia, through Dr. McQuillen. The fish is a representative of the Dipnoi, or double-breathers, like the Lepidosiren, being provided with both lungs and gills. The genus was long ago named by Agassiz, from isolated teeth found in the Triassic and Jurassic rocks of Europe. The *C. Forsteri* was discovered only a few years since, and was referred to Ceratodus by Dr. Günther, from the near resemblance of the teeth of the fish to the fossils described under that name. Another specimen, presented by Dr. S. C. De Vesy, of Williamstown, Dauphin Co., Pa., appears to be a fitting companion to the former. It consists of a fragment of coal shale, from the coal mines of Williamstown, with an impression which looks as if it might be that of the tail of a relative of the Ceratodus, or of a huge tadpole. Among the many enigmatic impressions occuring in the coal shales, is better defined than usual. It is 8¾ inches long and 6 inches at the widest part. Toward the upturned end of the specimen there are many strongly impressed conical pits, looking as if produced by prominent scale-like appendages, in the interspaces of which there are many minute impressions of the same form. The character of the fossil is very uncertain; it may be that of a batrachian or fish allied to Ceratodus. The coal period is well characterised by abundance of remains of both kinds of animals. Perhaps, however, the impression may be of vegetable origin."

Ancient Cave-dwellings in Kentucky.—Mr. F. W. Putman (in the eighth annual Report of the Peabody Museum of Ethnology, 1875) remarks: "That some of the caves were used as places of, at least, temporary residence was conclusively shown by my exploration of Salt Cave, which proves important in revealing a new phase in American archæology. This cave approaches the Mammoth Cave in the size of its avenues and chambers. Throughout one of the principal avenues, for several miles, were to be traced the ancient fire-places both for hearths and lights. For the latter purpose, small piles of stones were made with a hole in the centre of the pile to receive the bundle of dried fagots, perhaps smeared with grease. Bundles of these fagots, tied up with twisted bark, were found in several places in the cave; and canereeds, probably the remains of ancient torches of the same character with those found in the Mammoth, Short, and Grand Avenue Caves, were also very abundant. The most important discovery in this cave, however, was made in a small chamber, about three miles from the entrance, first noticed by my guides, Messrs. Cutlip and Lee. On the dry soil of the floor were to be seen the imprints of the sandalled feet of the former race who had inhabited the cave, while a large number of cast-off sandals were found, neatly made of finely-branded and twisted leaves of rushes.

Earthquake Phenomena of South Italy.—"The Academy" says that after studying the earthquake phenomena of South Italy, Professor Suess

has laid a paper on this subject before the Vienna Academy of Sciences. In this communication he describes the geological structure of Sicily and the southern part of the Italian peninsula. He concludes that the older rocks of this district, with the patches on the western coast, are to be regarded as a continuation of the Alps, while the western side of the peninsula represents a vast arrear of subsidence. He recognises three classes of earthquake-shocks in Sicily and Calabria: namely eruptive shocks, which have their centre in a volcano, and affect only the immediate neighbourhood; radial shocks, which radiate from the volcano in definite lines; and peripheral shocks, which appear to have no immediate relation with a volcano. His observations sufficiently show the connection generally existing between volcanoes and earthquakes.

The Patagonian Coal-fields.—We learn from "Sillimann's American Journal" (June), that on the Peninsula of Brunswick, in the Straits of Magellan, at a place called Vaqueria by Capt. Corey, rich beds of coal have been opened. The place is not far from the Chilian colony of Punta Arenas, lat. 53° 10′ S. and long. 70° 54′ W. (from Greenwich). The Chilian Government has conceded it to a French company. A detailed report has been published by M. F. Arnal, civil engineer. The coal is very compact, black, inflames easily, and burns without odour. There are three beds having an aggregate thickness of about 26 feet. The age of the beds is not stated, but as the coal is spoken of as related to the lignites, it is probably Tertiary or Mesozoic.

MEDICAL SCIENCE.

Intestinal Secretion.—A report was presented to the British Association by Dr. Brunton and Dr. Pye Smith. The report detailed a number of experiments which the committee had undertaken, and which were considered to prove the absence of influence on intestinal secretion through the splanchnic nerves, the pneumogastrics, the sympathetic above the diaphragm or the spinal marrow; and the probable influence of the ganglia contained in the solar plexus, though certainly not of the two semilunar ganglia exclusively. Also the independent occurrence of hæmorrhage and of paralytic secretion appeared, in the view of the committee, to point to a separate nervous influence on the blood-vessels and the secreting structures of the intestines. They also observed the occurrence of vomiting after section of both splanchnics and vagi.

On the Preservation of Anatomical Preparations.—Dr. Sesemann, of St. Petersburg, gives an account in the last number of Reichert and Du Bois Reymond's "Archiv fur Anatomie, Physiologie," &c., of his experience in the use of preserving solutions for anatomical preparations, which may be of some interest to zoologists as well as anatomists.

The Discoverer of Anæsthesia.—"Silliman's Journal" of July says that a bronze statue to Dr. Horace Wells, of Hartford, Connecticut, "the discoverer of anæsthesia," who died nearly a quarter of a century since, will soon be erected in Hartford. The statue is by the sculptor, Truman H.

Bartlett. The State of Connecticut appropriated five thousand dollars towards the monument, and the city of Hartford an equal amount. The expenses of the pedestal of the statue, which should also be of bronze, are not met by these appropriations, and funds are solicited of the public by the committee of the Hartford Medical Society, of whom Dr. E. H. Hunt, of Hartford, is chairman, and Dr. G. W. Russell, of the same city, treasurer. Dr. Wells "was the world's benefactor."

Value of Atropine in Opium Poisoning.—The "Lancet" of July 24 says that in a report of the Chinese Hospital at Shanghai, recently published, we find that the medical officer of the institution, Dr. Johnston, speaks almost rapturously of the value of the subcutaneous injection of atropine in opium-poisoning. During the last ten years upwards of 500 such cases of poisoning (nearly all suicidal) have come under his own observation, sixty-two having been recorded last year. Many of the most desperate cases rallied and recovered under the treatment advocated. The loss of life annually in China from the abuse of the drug must be appalling. Opium-smokers to the number of 360 were treated in the hospital in 1874, but the experience and results obtained were not encouraging, and Dr. Johnson expresses his opinion that it is a hopeless task to reclaim the confirmed opium-smoker.

Influence of Feeding over Development of Body.—In the course of his address to the British Association on Anthropology, Dr. Rollestone, F.R.S., made some interesting observations on this subject. Putting aside speculation, he said we placed our feet on firm ground when we say that in all savage communities the chiefs have a larger share of food and other comforts, such as there are in savage life, and have consequently better and larger frames—or, as the Rev. S. Whitmee puts it, when observing on the fact as noticed by him in Polynesia, a more "portly bearing." This (which, as the size of the brain increases within certain proportions with the increase of the size of the body, is a material fact in every sense) has been testified to by a multitude of other observers, and is, to my mind, one of the most distinctive marks of savagery as opposed to civilisation. It is only in times of civilisation that men of the puny stature of Ulysses or Agesilaus are allowed their proper place in the management of affairs. And men of such physical size, coupled with such mental calibre, may take comfort, if they need it, from the purely quantitative consideration, that large as are the individual skulls from prehistoric graves, and high, too, as is the average obtained from a number of them, it has nevertheless not been shown that the largest individual skulls of those days were larger than, or, indeed, as large as the best skulls of our own days; whilst the high average capacity which the former series shows is readily explicable by the very obvious consideration that the poorer specimens of humanity, if allowed to live at all in those days, were, at any rate, when dead not allowed sepulture in the "tombs of the kings," from which nearly exclusively we obtain our prehistoric crania. M. Broca has given us yet further ground for retaining our self-complacency by showing, from his extensive series of measurements of the crania from successive epochs in Parisian burial-places, that the average capacity has gone on steadily increasing.

METALLURGY, MINERALOGY, AND MINING.

Meteorites in 1875.—In a paper published in the "Geological Magazine" Dr. Walter Flight gives an account of two recent falls, one in America the other Hungary. He says, an account of a very sensational kind is given in the "Dubuque Times" of a brilliant meteor which was seen at Iowa City and other points of Central Iowa at this date. Its course was from S.E. towards N.W. It had apparently about half the diameter of the moon, and was accompanied by a beautiful train; it was seen to separate into several fragments, and after an interval of about three minutes three explosions were distinctly heard. One of the fragments of the meteorite fell about three miles south of the village of West Liberty in an open field, sinking, so it is stated, 15 feet into the ground. Of the 100 kilog. which have been found, the greater portion is in the Iowa State University Museum; 25 kilog. have been sent to Paris. Daubrée traces a resemblance between this stone and the aerolites of Vouillé and Aumale.—1875, April—Zsadány, Hungary. A preliminary note on this fall of meteorites has been communicated to the Natural History Society by Krenner, the Keeper of the Minerals in the Hungarian Museum at Pest. Their descent was attended with an explosion, and the peasants who were witnesses of the fall state that the fragments were cold at the moment they reached the ground. Nine fragments, rather smaller than walnuts, were collected, six of which weighing 144 grammes are in the possession of the above Society. The investigation of this aerolite has been undertaken by Wartha and Krenner; the former will subject it to analysis, the latter examine its mineralogical characters. It may be mentioned that the stones which fell at Dhurmsala in India (1860, July 14) are stated to have been so cold that they could not be held in the hand.

On Serpentine Pseudomorphs after Monticellite, a Lime-magnesia Chrysolite.—The pseudomorphs described recently in the monthly notices of the Academy of Berlin by Her Vom Rath are from the Pesmeda Alp, on Mt. Monzoni in the Tyrol. The syenite, dioryte and "augitic greenstone," which constitute the Monzoni peak, come up through limestone (of the Triassic formation) which is in part crystalline; and this limestone contains many crystallised silicates near its junction with the other rocks, viz., fassaite, vesuvianite, gehlenite, garnet, spinel, &c. In a high ridge adjoining the Pesmeda Alp, at a height of about 2,500 yards, the limestone, near its contact with "augitic greenstone," affords crystals of the form of monticellite, along with others of anorthite, garnet, and spinel. The monticellite crystals, some of which are two inches long, are all changed to serpentine. They occur mixed with fassaite, and with a blackish green spinel which is also in part serpentine. The colour of the pseudomorphs is light brown, yellowish, and occasionally white. The crystals within are irregular in texture and colour, as is well represented on a plate showing magnified sections. Vom Rath gives several excellent figures of the crystals. Unaltered monticellite has not been found at the locality, but it occurs massive (Breithaupt's batrachite) to the west of Pesmeda and to the south-east of Mt. Monzoni, near the junction of the limestone and syenite.

This massive kind is externally altered. Vom Rath also states that the locality of serpentine-pseudomorphs affords others of *monticellite altered to fassaite.* The crystals are an inch and less in size. They have sometimes a nucleus of serpentine or calcite. The fassaite pseudomorphism in all cases preceded the serpentine.

MICROSCOPY.

Papers of the past Quarter.—The following papers have been published in the "Monthly Microscopical Journal" for the months of July, August, and September:—

Notes on Bucephalus Polymorphus. By Charles Stewart, F.L.S., Hon. Sec. R.M.S., &c.—Measurement of Angular Aperture. By J. W. Stephenson, F.R.A.S., Treasurer R.M.S.—Notes on the Use of Mr. Wenham's Reflex Illuminator. By Henry J. Slack, F.G.S., Sec. R.M.S.—On Dr. Schumann's Formulæ for Diatom-lines. By W. J. Hickie, M.A., St. John's College, Cambridge.—Number of Striæ on the Diatoms on Möller's Probe-Platte. By F. Kitton, Norwich.—On Bog Mosses. By R. Braithwaite, M.D., F.L.S.—On the Unit of Linear Measurement. By Rev. D. Edwardes, M.A., St. Chad's College, Denstone.—The Microscope and its Misinterpretations. By John Michels.—Double Staining of Wood and other Vegetable Sections. By George D. Beatty, M.D., of Baltimore.—On Conjoined Epithelium. By S. Martyn, M.D., F.R.C.P., Lecturer on Medicine and Pathological Anatomy, Bristol Medical School.—The Microscopic Germ Theory of Disease; being a Discussion of the Relation of Bacteria and Allied Organisms to Virulent Inflammations and Specific Contagious Fevers. By H. Charlton Bastian, M.D., F.R.S., Professor of Pathological Anatomy in University College.—A Modification of Dr. Rutherford's Freezing Microtome. By William James Fleming, M.B., Assistant to the Professor of Physiology, Glasgow University.—On the Origin of Life. By Lionel S. Beale, M.B., F.R.S.—On the Existence of Flagella in Bacterium Termo. By W. H. Dallinger, F.R.M.S., and J. J. Drysdale, M.D., F.R.M.S.—A New Mode of Illuminating for High Powers. By Dr. Whittell.—The Resting Spores of the Potato Fungus. By Worthington G. Smith, F.L.S.

PHYSICS.

Action of Magnets in Geissler Tubes.—This has been recently investigated by M. J. Chautard, who has studied somewhat at length the effect of a magnet on rarified gases enclosed in capillary tubes, illuminated by an induced current. The gases or vapours employed were H, N, O, CO_2, CO, C_2H_4, S, Se, I, Br, Cl, SO_2, SiF_4, $SnCl_4$. Bodies of the chlorine family are those which gave the most concordant and brilliant effects. An increase of temperature diminishes the action of the magnet. This is shown by allowing the current to pass for some time, when the magnetic influence is en-

feebled or destroyed. The presence of the gas is an important element to be considered, as by varying it the current may be intercepted or the appearance of the light greatly altered. Similar effects are attained by varying the strength of the current, and are most marked when the current is feeble. The phenomena are the same whether a Holtz machine or coil are used as a source of electricity, and are independent of the direction through the coil or gas. The form of the armatures is important; they should be plain and surround the tube for the greater part of its length. The effect of a single pole is slight, or of both poles when more than five millimetres distant from the tube.

Different Forms of Light for Lighthouses.—At the recent meeting of the British Association Sir W. Thomson and Mr. J. Hopkinson read a paper on "Methods for giving Distinctive Characters to Lighthouses." Sir William Thomson read the first portion. Speaking of coloured lights, he said they would not be of value except for marking a specific direction, and for this colour had been the only successful invention. At Ardrossan a ship went ashore through a mistake of a light in Ardrossan for a harbour light. There was a red light in an apothecary's shop in Ardrossan, and the pilots had told him that they regularly steered in by the "light of the doctor's shop." The greater speed of steam traffic required that light should be seen at a greater distance and recognised sooner, and the lights must be more powerful. Rapid advances have been made in the English lights, particularly in respect to their power, but more distinctions were required. Many harbour lights were now confounded with gas. Now there was a blaze of gas, and it was, in some cases, impossible to make out which was which. The authorities were exceedingly sluggish in making such changes as were required in the appliances. The eclipse light, which he advocated, would signal three lights, which he described as "short, short, long," indicating the periods for which the light would be eclipsed. Mr. Hopkinson had also invented a revolving light, which cost little more than the ordinary revolving apparatus, but which would give a double flash or a treble flash, instead of the one flash of the ordinary revolving apparatus.

Effects of Stress on the Magnetism of Soft Iron.—Sir W. Thomson read a paper at the meeting of the British Association, in continuation of his essays before the Royal Society. In the physical laboratory at Glasgow University he had stretched steel and soft iron wire about twenty feet long from the roof. An electro-magnetic helix was placed round a few inches of the wire, so that the latter could be magnetised when an electric current was passed through the former; the induced current thus produced in a second helix outside the first being indicated by a reflecting galvanometer. When steel wire was used, the magnetism diminished when weights were attached to the wire, and increased when they were taken off; but when specially made soft iron wire (wire almost as soft as lead), the magnetism was increased when weights were put on, and diminished when they were taken off. Afterwards he discarded the electrical apparatus, and by suspending a piece of soft iron wire near a magnetometer consisting of a needle a small fraction of a grain in weight, with a reflecting mirror attached, the wire was magnetised inductively simply by the magnetism of the earth, and changes in its magnetism were made by applying weights and strains, the changes being then indicated by the magnetometer.

Polarisation of Light by Sugar: a Peculiar Effect.—M. Maumené has described to the French Academy, see ("The Academy," July 24) a series of experiments on inverted sugar, so called from its action on polarised light. Cane sugar consisting of $C_{12}H_{22}O_{11}$ is crystallisable, and produces a right-handed rotation of polarised light. Inverted sugar stated to be composed of $C_6H_{12}O_6$ is not crystallisable, and gives a left-handed rotation. M. Maumené finds inverted sugar has no constant composition, but is a mixture of various proportions of glycose, chylariose, and neutral sugar. Acting upon very white Narbonne honey with alcohol of 90°, then cooling the solution to near zero C., separating a heavy layer, adding water and filtering, gives a fluid which is easy to examine with a saccharometer and marks zero—it contains neutral sugar. Acting upon this sugar with lime water, passing through it a current of carbonic acid, which occasions a pure blue precipitate of carbonate of lime, and filtering, affords a solution that gives a right-handed rotation of 8° to 10°. The substance left on the filter was divided into two parts, and to one water was added, dissolving the chylariose and giving a very white precipitate of carbonate of lime. The clear fluid produced a left-handed rotation of 5°, equal to 47°·5 for a volume of 100. The insoluble matter diffused through water carbonated and filtered showed 13° left rotation, or 91° for a volume of 100. M. Maumené adds that inverted sugar burns much more readily than common sugar—a fact of importance in analysis when the quantity of ash has to be ascertained.

Spectra of Stars.—It appears that the late Professor d'Arrest had concluded the observations on this point before his death. The conclusions he arrives at are: (1) that the third type of spectrum (channelled spaces) is not exclusively confined to orange or red stars, and that several deep-hued orange stars give an ordinary spectrum. Perception of colour (especially red) depends so much on the eye of the observer that Professor d'Arrest's result must be taken rather as a caution against a hasty generalisation than as disproving any connexion between colour and the nature of the spectrum; (2) that the fourth type of spectrum is much more closely connected with deep orange or red stars, and that the bands in this spectrum may be resolved into a number of fine lines; (3) that as a rule such striking spectra accompany variability in a star; (4) that no general difference can be traced between the spectra of stars in one part of the heavens and of those in another, so that there is no truth in the assertion that the red and yellow are wanting in all the stars of Orion.

Propelling Ships by Utilising the Action of Waves.—A paper of great interest is that read before the British Association by Mr. Beuachamp Tower, who described a contrivance for obtaining motive power from wave-motion. A heavy weight, supported upon springs, vibrates in periods of the same length as the wave-periods. By means of gearing the motive power obtained from the rising and falling of the weight is made to propel the vessel.

New Property of Aluminum.—M. E. Ducretet observes ["Journ. de Phys." iv. 84] that on inserting in a galvanic circuit a voltameter with two electrodes, one of aluminum, the other of platinum, different effects are obtained according to the direction of the current. When the aluminum receives the negative electricity the water is decomposed and the current traverses the circuit freely. But on reversing the current the decomposition

ceases and scarcely any electricity is transmitted. An electric bell inserted in the circuit in the first case rang violently, and in the second case did not move. Replacing the bell by an iron wire, in the first case it was melted, and not even heated in the second. A galvanometer gave in one case a deflection of 22° and in the other of only 2°. The effect is produced instantly; it is constant and durable whatever the number of inversions of the current. If other metals are used instead of platinum, they are deposited on the aluminum and interfere with the experiment. This stoppage of the current is not produced by a plate of gold, silver, platinum, copper, zinc, magnesium, tin, lead, &c., replacing the aluminum. A partial effect is produced with iron, but the surface is soon altered, with the disengagement of a bad odour. As to the aluminum, its surface appears to be preserved by a slight layer of alumina, which is formed immediately, and remains, in spite of the inversion of the current. Many practical applications of this property suggest themselves. Two messages may be sent over a telegraph line at the same time in opposite directions by using two voltameters with the aluminum on opposite sides. All trouble from variable resistance is thus avoided.

Effects of Heat on the Structure of Steel Rods and Wires.—A paper was read before the British Association by Professor W. F. Barrett, in which he said he found that if steel of any thickness be heated by any means, at a certain temperature the wire ceases to expand, although the heat be continuously poured in. During this period also the wire does not increase in temperature. The length of time during which this abnormal condition lasts varies with the thickness of the wire and the rapidity with which it can be heated through. It ceases to expand, and no further change takes place till the heat is cut off. When this is done the wire begins to cool down regularly till it has reached the critical point at which the change tock place on heating. Here a second and reverse change occurs. At the moment that the expansion occurs, an actual increase in temperature takes place sufficiently large to cause the wire to glow again with a red-hot heat. It is curious that this after-glow had not been noticed long ago, for it is a very conspicuous object in steel wires that have been raised to a white heat and allowed to cool.

Supporting Crucibles in Gas Furnaces.—This important subject was lately brought before the Chemical Society by Mr. C. Griffin. In the author's gas-furnace, a description of which was communicated to the Society in 1870, the perforated plumbago cylinder, and the trivet-grate on which the crucible is supported, are liable to break when white-hot, occasionally giving much trouble; moreover, the latter has the disadvantage of interfering with the direct action of the flame on the crucible. This, however, is entirely obviated by the new burner, in which a space is left round the central jet which has fitted over it an atmopyre similar to those used in Hofmann's combustion-furnace. The bottom of the crucible rests on this, and the plumbago cylinder is thus relieved of all pressure. These new burners are very economical and of great power, a small one, burning 20 feet of gas per hour, being capable of melting half-a-pound of cast-iron in thirty-five minutes; or of heating a muffle, 5 inches long and 3 wide, to a temperature sufficiently high for assaying. Several varieties of the furnace were exhibited, one of which was in action.

ZOOLOGY AND COMPARATIVE ANATOMY.

Rate of Growth in Corals.—An interesting account of the rate of growth of corals is given in a letter addressed to Professor Dana by Professor Le Conte, and published in "Silliman's American Journal" [July 1875]. The following portion is of importance:—"Professor Agassiz and his party were at Fort Jefferson, Tortugas. Dr. William L. Jones and myself had gone to examine a little island about eight or ten miles to the north-west. On returning to Fort Jefferson in a small boat, when about half-way between the two islands, and in the still shoal water on the inside of the line of reefs, to our great surprise the boat suddenly grounded on the close-set prongs of an extensive grove of madrepores (*Madrepora cervicornis?*). On examining closely the trees of this grove, we found: 1. That the prongs were far more thickly set than is usual in this species; 2, that all the prongs not only of the same tree, but of all the trees of the whole grove, grow up to nearly the same level, which at the time examined was very near the surface; 3, that all the prongs at that level were dead for a distance of one to three inches from the point. The lower limit of death seemed to be a *perfectly horizontal plane.* The dead points rose above it to various distances not exceeding three inches. We rowed around the margin of this grove for a considerable distance, and found everywhere the same phenomena. I satisfied myself that the whole grove, for hundreds of acres in extent, had been clipped in a similar manner. On subsequent inquiry at Key West, I learned that the mean level of the ocean, owing probably to the prevalence of certain winds, was higher during one portion of the year than during the other. It became evident, therefore, that during the high water the living points of the madrepores grow upward until the descending water level exposes and kills them down to a certain level. With the rise of the mean level again new points start upward, to be again clipped at the same level by the descending water. The levelness, the thick setting, and the deadness of the points are all thus completely accounted for. It is precisely the phenomena of a clipped hedge."

American Zoology.—We learn from the "Academy" (July 24) that Drs. Coues and Gill are preparing a volume on the "Mammals of North America," uniform with Dr. Baird's work on the "Birds." Mr. D. G. Elliott has returned to Europe with the intention of completing his long-planned "Monograph of the Felidæ," and we are glad to learn that he contemplates a re-issue in quarto form of his splendid but somewhat inaccessible "Monograph of the Phasianidæ."

The Date of the Dodo and Solitaire, &c.—M. A. Milne-Edwards has written a short paper on this subject in a recent number of the "Comptes Rendus." He says that a "manuscript entitled 'Relation de l'île Rodrigue,' found in the Ministère de la Marine, along with evidence that it was published anterior to 1730 and probably not earlier than 1729, describes the species of the island existing at the time it was written, and among them all the species now known to be extinct, including the *Solitaire* and the extinct species named by A. Milne-Edwards, *Erythromachus Leguati*, *Ardea megacephala*, *Athene murivora*, and *Necropsittacus Rodericanus.* In 1761, when the

astronomer Pingré was living there, the solitaires had become so rare that he knew of them only from report—none having been seen by him. The extinction of the birds probably went on rapidly between 1730 and 1760, as may be inferred from the documents at the Ministère de la Marine. The land-tortoises became extinct somewhat later. These tortoises were part of the regular provisions of the shipping of the Compagnie des Indes. M. Desforge-Boucher, in his reports to the company in 1759 and 1760, enumerates the vessels sent for the land-tortoises, and shows that they took away in less than eighteen months over 30,000. It is not surprising," the author remarks, "that these animals, on so small an island, notwithstanding their fecundity, could not withstand such means of destruction. Hungry man was the agent of extermination both for the tortoises and the birds." These gigantic land-tortoises, while extinct on the islands of Mauritius, Rodriguez, and Réunion, are living on that of Aldabra, another of the Mascarene Group. But there is danger of its extinction there. To prevent this, if possible, a memorial has been addressed to the Governor and Commander-in-Chief of Mauritius and its dependencies, signed by the presidents of the Royal and Royal Geographical Societies of London and other men of science, calling the attention of the Colonial Government to the subject, and asking that some means may be devised for "saving the last examples of a contemporary of the dodo and solitaire."

An Improved Mode of Preserving the Bodies of Animals has been devised by Professor A. E. Verrill, and is described by him in "Silliman's American Journal" (Sept. 1875). He says:—"During the summer numerous experiments were made by Professor W. N. Rice and the writer, to ascertain the effects of various chemical preparations upon marine invertebrates. The special objects were: First, to improve the methods of preserving specimens for museum purposes, or to devise new methods; second, to ascertain the best means of killing in an expanded state species that ordinarily contract badly when put directly into alcohol. Besides numerous negative results, several of value were obtained. Numerous very perfect and beautiful preparations of *Actiniæ* (chiefly *Metridium marginatum*), in a state of nearly complete expansion, were made by slowly adding a saturated solution of picric acid to a small quantity of sea water, in which they had been allowed to expand. When fairly dead they were transferred to a pure, saturated solution of the acid, and allowed to remain from one to three hours, according to size, &c. They were then placed in alcohol of about 60 to 70 per cent. for permanent preservation. The alcohol should be renewed after a day or two, and this should be repeated until the water is all absorbed from the specimen. Hydroids (*Tubulariæ* thus preserved are especially beautiful) and most kinds of jelly-fishes can be easily and beautifully preserved in the same way, but with these the specimens may usually be placed alive directly into the acid, of full strength. Even delicate ctenophoræ (*Mnemiopsis*, *Idyia*, &c.) can be thus preserved so as to make fair specimens. With osmic acid we did not succeed so well, for the specimens contracted more, and finally became so darkly stained as to render them useless. Hydrochloral was also experimented with. It proved to be useless as a permanent preservative of marine invertebrates, as it apparently had a caustic or solvent

action, and all the soft parts gradually dissolved, but without putrefaction."

North American Oniscidu.—M. A. Stuxberg has a paper on the North American oniscida in the "Ofversigt K. V. Ak. Förhandlingar," 1875, No. 2, Stockholm, reviewing the described species, and adding descriptions of several new species.

Another gigantic Cuttle-fish has been described in "Silliman's American Journal" (Sept.) by Professor A. E. Verrill. He states that the Rev. M. Harvey had been informed by Mr. G. Simms that he (Mr. S.) "examined the creature a few hours after it went ashore, but not before it had been mutilated by the removal of the tail by the fishermen, who finally cut it up as food for their numerous dogs; and that the long tentacular arms were 26 feet long and 16 inches in circumference (probably meaning at their broad terminal portion); the short arms were 'one-third as long as the long ones, and about the same in circumference; the back of the head or neck was 36 inches in circumference' (evidently meaning the head, behind the basis of the arms); the length of the body 'from the junction to the tail' was 10 feet (apparently meaning from the anterior edge of the mantle to the origin of the caudal fins). He thinks the tail, which had been removed, was about one-third as long as the body, but this is probably over-estimated, judging from the Logie Bay specimen (No. 5 of Professor Verrill's former papers), in which it was about one-fifth, but it may have been cut off above its proper base. Allowing one-fifth also for the length of the head, the total length would be about 40 feet, the head and body together being about 14. The large sucker, in my possession, is 1 inch in diameter across the denticulated rim, and in form and structure agrees closely with those previously described and figured by me from the tentacular arms of Nos. 4 and 5. The jaws are still attached together in their natural position by the cartilages. They agree very closely in form with the large jaws of *Architeuthis princeps*, but they are about one-tenth smaller. The upper jaw measures 111$^{\text{mm}}$ in height (front to back); 88$^{\text{mm}}$ from tip of beak to front edge of palatine laminæ; 20$^{\text{mm}}$ from tip of beak to the base of the notch. The lower jaw measures 96$^{\text{mm}}$ in total length; 80$^{\text{mm}}$ from tip of beak to front edge of laminæ; 19$^{\text{mm}}$ from tip to base of notch. From the close agreement of these jaws with those of *A. princeps*, there can be very little doubt that they belong to that species; and if so the measurements given will be of great importance as affording additional knowledge of the approximate form and proportions of this the largest known species."

INDEX.

END OF VOL. XIV.

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